The Chestnut and Its Weevil

Nut Culture for North Carolina

ISSUED BY THE
NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

INCLUDING

THE FERTILIZER CONTROL STATION

AND THE STATE WEATHER SERVICE,

UNDER THE CONTROL OF THE

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RALEIGH, N. C.

THE CHESTNUT AND ITS WEEVIL.

By GERALD McCARTHY, Entomologist.

When the country comprised within the present State of North Carolina was first settled by white men the chestnut was the most common forest tree all through the west-central and western districts of the State. In the foot-hills of the Blue Ridge mountains these trees were often found of gigantic size. The woodman's axe, casual fires, and the ravages of the root disease have wrought much havoc in these grand forests, but there yet remain sufficient trees to make the gathering of chestnuts one of the principal occupations during the fall months of the people of the western part of the State. Formerly chestnuts were shipped by the car-load to Northern markets from towns along the Western N. C. Railroad, but the business is now greatly curtailed. Of recent years there has been an ever increasing complaint about the wormy condition of the nuts when they reach their destination. Nuts apparently sound when shipped are often found so badly infested by weevils as to be unsalable when the consignment reaches market.

The cultivation of chestnuts in orchards, as apples and other fruits are grown, is as yet scarcely begun in this State. The varieties so far planted in orchards are almost wholly the Mammoth Japanese and Spanish Sweet. The quality of both these species is far below that of the native forest chestnut. These foreign varieties, especially the Japanese, seem to be less damaged by the weevil than the native nut, but they are by no means exempt. In order to learn the present condition of the chestnut interest, a circular was recently sent out from this Station to about one hundred persons within the State, living in neighborhoods where the native chestnut is yet abundant. Copies of this circular were also sent to prominent horticulturists and entomologists in other States, soliciting replies to the following questions concerning the chestnut weevil:

1. How long has the chestnut weevil been known in your locality?
2. Which variety of chestnut—American, Spanish or Japanese—is most attacked by the weevil?
3. What proportion of mature nuts are found wormy?
4. How soon after gathering the nuts do the worms appear?
5. When does the parent beetle appear on the trees?
6. Are worms found in stored nuts in spring time?
7. Can wormy nuts be utilized in any way?
8. What remedies or preventive measures have been tried for the weevil?

Replies to Circular.

Replies were received from nearly all persons addressed. Abstracts of the more important of these are annexed.

Allen Warren & Sons, Greenville, N. C. (Eastern District.)—We have known the weevil ever since we can remember. The Japanese is most attacked. No worms apparent when burr first opens, but they appear in ten to fifteen days. When we gather the nuts we place them on a sieve and plunge it into boiling water for a few seconds. The nuts are then spread out to dry before being packed. This prevents the appearance of worms.

N. W. Craft, Shore, N. C. (Western District.)—I have known the weevil for fifty years. It was as destructive when I was a boy as it is now. Only the native chestnut is grown here. Some seasons the weevil is more abundant and destructive than in others. On an average one-tenth of the crop is ruined by weevils. The weevils are in the nut when it falls and soon after come out. Live worms are rarely found in nuts kept over winter. Know no use for wormy nuts. The nuts are so abundant here that we do not take time to gather them all.

H. P. Kelsey, Linville, N. C. (Western District)—Have known the weevil in the mountains for fifteen years. The American chestnut is most attacked. From one-eighth to one-half the crop is annually destroyed by the weevil. They begin to issue from the nuts soon after gathering and may continue to come out during the winter. Have often found them in the nuts in spring. Have often seen the nuts scalded in boiling water to destroy the worms. I have seen the female insect ovipositing on the chinquepin, and more rarely on the chestnut. Know of no remedy.

R. L. Patton, Swannanoa, N. C. (Western District.)—Have known the chestnut weevil as long as I can remember, about thirty years. It does more damage now than formerly. I know only the native chestnut, which is abundant here. From one tenth to one fifth of the crop is wormy, when the nuts fall. If left to lie they soon all become wormy. If the nuts are gathered as soon as they fall and dried in the sun it saves most of them.

Calvin J. Cowles, Wilkesboro, N. C. (Western District.)—Have known the weevil for sixty years. It was as common sixty years ago as now. It also infests the chinquepin. Nuts are not wormy when they first fall, but if not sun dried at once will become so in about two weeks. I have noticed the beetle only on the chinquepin. It seems to do its work while the burrs or nuts are young and green. Only dead worms are found in nuts kept over winter. They seem to mature about the time the nut falls. They then cut their way out and bury themselves in the ground. Wormy nuts can be utilized only by feeding them to hogs. The best treatment for chestnuts is as follows: Dip them into boiling salt water long enough to heat but not cook the nuts. Then spread in the sunshine for a few

days. After this let them dry in the shade until thoroughly dry. If it is necessary to ship at once, the sun-dried nuts may be bagged provided all moisture is evaporated from the outside, otherwise they will mildew. The brine keeps the shell soft and pliable and the kernel more palatable than when not thus treated.

P. J. Berckmans, Augusta, Ga.—The native chestnut is not found here. Have cultivated the Spanish and Japanese varieties for years, but never found them attacked by the weevil.

H Ridgely, Dover, Del.—Have known the chestnut weevil as long as I can remember. The American is most attacked. From thirty to forty per cent. of the crop is wormy. So extensive is the damage that now few dealers will buy chestnuts. The worms appear in about ten days after the nuts are gathered. A remedy is much needed.

Chas. Black, Hightstown, N. J.—The chestnut weevil has been more or less troublesome as long as I can remember. In some seasons they are worse than in others. The Japanese and Spanish were most attacked this year, having fully fifty per cent. weevilly. The weevils make their appearance soon after gathering the nuts, and work for a month or so. The live maggots are never found in spring in dried nuts, but may be found in nuts which have been kept moist, as they must be when intended for seed. The weevilly nuts might be fed to swine, no other use for them. Know of no remedy for this pest.

J. W. Kerr, Denton, Md.—The chestnut weevil has been known here further back than I can remember. The American and Spanish chestnuts are both attacked—the latter probably most. The Japanese nut is nearly exempt. From ten to twenty-five per cent. of crops is annually destroyed. I do not know the reason, but with me it is a rare thing to find a wormy nut among the Japans.

R. C. Hewson, Penn Yan, N. Y.—The chestnut weevil has been known here for a long time. From one-tenth to one-twentieth of the crop of the native nut is annually destroyed by the weevil. The insect resembles the plum curculio and can be defeated by fumigating with creosote or carbolic acid.

L. A. Goodman, Westport, Mo.—The chestnut weevil has never done any damage here. I have about fifty bearing trees of the American variety, about eighteen years old.

T. T. Lyon, South Haven, Mich.—I have known the chestnut weevil in Michigan for sixty years. There are but few indigenous chestnut trees in this State. I have the only bearing orchards of the Japanese and Spanish chestnuts in this vicinity. These have been in bearing for only three or four years and the weevil has not yet discovered them. From five to twenty per cent. of the crop of the native variety is annually destroyed by the weevil. About October 1, 1893, I received four pounds of chinquepins from Tennessee. I found them all infested and the mature larva just coming out. The nuts were burnt.

T. V. Munson, Denison, Texas.—There are no bearing chestnut

orchards in this vicinity. There is, however, a weevil about the size of a pea weevil which infests acorns, hickory nuts and pecans. Live-oak acorns are especially liable to attack. This may be the same beetle which infests chestnuts, but I call it the acorn weevil.

J. Alexander Fulton, Dover, Del.—The chestnut weevil has been very bad here during the last two years. The complaint as regards the Spanish variety is universal. We have few bearing trees of the other varieties. I have a very fine tree, about twenty-five years old, and last year the worms destroyed every nut. The nuts were infested before becoming ripe. The weevil enters at the bottom of the pod or burr, making a round, clear hole. I am glad you have taken up this matter, for unless a satisfactory remedy can be found I am certain our chestnuts are doomed—all varieties will share the same fate.

Wm. P. Corsa, Washington, D. C.—From personal recollection and family history I know that the chestnut weevil has been a pest in the neighborhood of New York city for over ninety years. In Virginia, the chinquepin is more attacked than any other variety of chestnut. I once saw, near Fulton, Delaware, upon just-opening burrs of the chinquepin, large numbers of the beetle, but was unable to determine whether or not they were ovipositing. The date was about September 1. The most successful remedy is to scald the nuts as soon as gathered and then dry well in the sun before storing them. To scald, place a bushel or so of nuts into a wash-tub and pour in enough boiling water to come one or two inches above the nuts. Stir vigorously with a stick and the weevilly nuts will come to the surface; skim these off and destroy them. About five minutes in the water will be sufficient. Scoop the nuts out with the hands and place them in sacks, about half-filled, in the sun. Shake and manipulate freely to hasten drying. The kernels of nuts thus treated remain soft and tender all winter, and do not get flinty as those not treated do. Of course nuts intended for planting must not be treated in this way.

The Chestnut Weevil, *Balaninus proboscoideus*, Fab.

Fig. 1.—Chestnut Weevil.

The chestnut weevil is a member of the curculio tribe of the beetle family of insects. The genus *Balaninus* includes seven American species, all of which are nut weevils, viz.: *B. proboscoideus*, which attacks chestnuts and chinquepins only; *B. rectus*, chestnuts and acorns; *B. quercus*, acorns only; *B. nasicus*, acorns only; *B. carya*, hickory and pecan nuts only; *B. uniformus*, acorns only; *B. obtusus*, hazel nuts only. All of these species are more or less common throughout the Atlantic, Gulf and Middle States, or wherever their food plants are indigenous. *B. proboscoideus*, *B. quercus* and *B. carya* are most abundant in the South

Atlantic region. All the species of *Balininus* are much alike, and are characterized by the extreme length and slenderness of the beak or snout. In the male beetle the snout is about the length of the body; in the female it is twice as long as the body. The snout is used to pierce through the thick and immature husk or burr of the nut and gouge out a place for depositing the egg. As the husks of this class of nuts are very thick the beak must be proportionately long. The chestnut weevil is yellowish, with rusty spots and lines on the wing covers. It is about the size of the common pea weevil. The footless grub is white or cream-colored, with a red or yellowish head, about half an inch long when full grown, nearly cylindrical.

The winged beetles appear on the chestnut trees about the time these begin to bloom or a little after. The female lays her eggs, as already mentioned, by piercing the young ovary or husk and deposits from one to four eggs in each. The eggs hatch in a few days. The shell of the nut subsequently forms and hardens around the grub. The hole seen in the shells of mature nuts are always made by an escaping grub, never by one entering. The number of eggs laid by each female is not known, but is probably not less than fifty nor more than one hundred. As soon as the eggs are laid the winged insect dies and no more are seen until the next spring, there being but one brood each year. In the latitude of North Carolina and further south the grub reaches maturity soon after the nuts are ripe and the burr opens. Under ordinary circumstances the grub escapes from the nut within ten days after the burr falls from the tree. It then enters the ground and changes to the *pupa* state, in which it remains dormant during the winter. In spring it issues as a winged beetle to produce eggs for the next brood of grubs, and so on from year to year. In this latitude no live worms are found in stored nuts after Christmas, unless these nuts have been artificially kept cool so as to keep the worm in a sort of torpor. Further north it is possible the worms remain alive in the nut during winter, escaping in the spring. This is more apt to happen when cold weather comes early, by which the worms are benumbed before reaching maturity. The worm will very likely remain in the ground as a dormant pupa during the succeeding summer, coming forth as beetles the following year. This will account for the fact that one year the nuts are generally destroyed by the worms and the next year but few are damaged.

Remedies.

As regards the native or forest chestnut under ordinary circumstances there is no practicable treatment except to sort out the sound nuts from those ruined by the worms as shown by the holes in the shells. Some of our correspondents have advised that the nuts be thrown into water, hot or cold, and those that float be skimmed off and thrown away. Hand picking as far as possible should follow

this plan. In this way wormy nuts can to a great extent be thrown aside, and only the whole ones be shipped. A very convenient plan is that described on p. 270 by Wm. P. Corsa, of Washington, D. C. To prevent the escape of the worms into the ground, the nuts should be gathered as soon as they fall and stored in tight boxes or bins from which the worms cannot escape. After twelve or fifteen days they may be killed by fumigating the bin or box with carbon bisulphide. Use eight ounces of this to a ton of nuts and cover the box or bin tightly for twenty-four hours. Then expose to the air until the carbon bisulphide has all evaporated. It will not hurt the edible nuts at all. It must be remembered that the worms do not pass from nut to nut but always remain in the nut upon which the egg was originally laid. If *all* the nuts were gathered as soon as they fall and subjected to this treatment or the scalding process described by several of our correspondents, the brood of beetles for the next year would be greatly reduced if not practically exterminated. It is, however, certain that a portion of the grubs which enter the ground in the fall may remain therein during the whole of the succeeding year—coming forth the second year, hence this treatment should continue for two sucessive seasons. But under our present unsystematic management of forest lands no such thorough treatment is practicable. It is likely then that the damages of the chestnut weevil will continue until the wild native nuts are wholly excluded from the market except as to nuts sorted over by hand as already advised. A brand of nuts known to be hand-sorted will always sell. There are one or more natural parasites of this insect, but these parasites do not seem to reduce the numbers of the pest, though undoubtedly they greatly moderate its noxious activity. Real and trustworthy preventive measures become possible only when chestnut trees are grown in orchards and given the necessary care given to other valuable fruits. Where such a course is pursued the insect can be as easily controlled as its near relative, the plum curculio, and by much the same means. The use of London purple or Paris green—one pound to two hundred gallons of water—will be found very useful if applied after the trees have passed out of full bloom or a little later. The spray must be directed especially towards the flowers and young fruit. Jarring the trees during the blooming period as is now done for the plum curculio will prove as beneficial in this case as for the plum. The nuts as soon as the burr opens should be gathered and scalded as recommended. When these measures are carefully and thoroughly carried out, there will be little damage from the weevil. To make the treatment easy and therefore more practicable only dwarf growing varieties or trees should be planted in chestnut orchards. Where edible nuts other than the chestnut are attacked by weevils substantially the same treatment advised for the chestnut will be found satisfactory, as all these weevils are closely related and for practical purposes may be regarded as identical.

APPENDIX.

[NOTE: In order to make the recommendations, given in this bulletin, for combatting nut weevils more practical, the following excellent paper on orchard culture of nuts is reprinted from the 13th Annual Report of the N. C. Horticultural Society.]

NUT CULTURE FOR NORTH CAROLINA.

BY W. A. TAYLOR, ASSISTANT POMOLOGIST, U. S. DEPARTMENT OF AGRICULTURE.

The subject of nut culture is a new one to most American fruit-growers. Until recently our almost boundless forests, rich in nut-bearing species, have yielded a supply sufficient for the demands of our markets. The river bottoms of Louisiana and Texas have yielded their tribute of pecans; the valleys of more northern States have supplied an abundance of black walnuts and butternuts; the forests of Appalachian ridges have furnished toothsome chestnuts, which have found sale at prices usually profitable to the collector. While the shagbarks of New England and the Central States have long been staple commodities in city markets, none of these have been planted or cultivated for their nuts until recently, because of the belief that their culture could not be made profitable.

But the progress of our impetuous civilization has gradually worked a change in forest conditions. The axe has given way to the saw-mill, and the fire from the burning log-heap has not ceased its destruction at the line-fence of the settler. Our forest area is rapidly diminishing, and the area of nut-bearing trees decreases at even a faster rate because of the greater value of the timber of most nut-bearing species. The near future is sure to witness a change in the source of the supply of nuts now demanded by our city markets similar to that which has been witnessed in regard to our small fruits, *i. e.*, the wild nuts will be replaced by the larger, finer and in every way superior products of cultivated plantations.

From the fact that choice nuts can be shipped for long distances, it is probable that the nut culture of the future will become localized, both as regards species and varieties. Certain localities will be found to produce a superior product of the pecan, the walnut, the chestnut, the hazel and the shell-bark, and the production of those particular types will become specialties in those localities. This tendency is already strongly marked in California, where, after a quarter of a century of somewhat indiscriminate planting, it has been found that the Persian walnut (*Juglans regia*) and the almond cannot be profitably grown in the same climates, but succeed admirably in regions not widely separated.

It is therefore of the utmost importance that planters study their conditions and select species suitable to their localities before embarking in nut culture on an extensive scale. As in all fruit culture, only careful experiment can settle uncertain points. It is with a view to encourage and aid in directing such experiments that the following suggestions are offered to North Carolina nut planters:

Of the many nuts found on our markets, not all are worthy of attention of the cultivator at the present time.

The black walnut, butternut, mockernut (*Hicoria tomentosa*) and the big shell-bark (*Hicoria sulcata*), though of some value, are not worth planting for their nut product. Our native chestnut, as commonly found, may be included in the same list, though a few choice varieties are worth a trial.

The nuts which are believed to be worth planting in North Carolina for market are the pecan, the Japanese and European chestnuts, and perhaps the Persian walnut.

Chestnuts.

Because of their large size, the Spanish and Japanese chestnuts find ready sale in our markets at good prices. Neither of them is equal to our native chestnut in flavor, but considerable quantities are imported and sold by roasters from stands on our city streets. They sell for about twice as much as our native varieties. Of the two species the Spanish is of better quality than the Japanese, though the latter is the larger nut and the tree comes sooner into bearing. Both can be quite easily grafted on the American chestnut, either by cleft grafting at the crown or by whip grafting the top or branches. They will probably succeed wherever the native chestnut thrives, and are therefore suited to the higher portions of the State, including the ridges of the piedmont and mountain regions. For the present their planting should be confined to experimental plots, as it is highly probable that American varieties of these species will soon be developed which will supersede them in our markets. Two such have already come to notice, both of the Spanish type—the Paragon and Ridgely. The Paragon originated in Germantown, Philadelphia, and is a large nut of good quality. The Ridgely, of which the original tree stands near Dover, Delaware, is a little smaller, but is reported to be very productive and of good quality. A variety that will yield nuts as large as the Paragon, and equal to our native chestnut in quality, is the *desideratum* of our nut-growers now. The originator or discoverer of such a tree has both honor and financial recompense awaiting him.

Of the imported European varieties Numbo has proved most valuable thus far, enduring the winters and yielding good crops of large nuts in eastern Pennsylvania. The best Japanese varieties yet tested are the Giant, Early Prolific and Superb—all large nuts.

Pecan.

This tree, which is native to the river bottoms of the lower Mississippi valley, Texas and Mexico, is our most promising indigenous species. It occurs as far north as Davenport, Iowa, and the tree grows to a large size in the valley of the Wabash. Occasionally planted trees have endured the winters and borne some nuts as far north as Philadelphia, but there is little probability that large thin-shelled pecans can be produced north of central Virginia. In North Carolina it will probably succeed best at elevations less than five hundred feet above sea-level. The tree requires rich soil and prefers moist alluvial ground that is rarely flooded. It will grow well on dry soil if rich and not too porous. The trees should be planted to stand not closer than thirty-five or forty feet apart each way. Unless the little trees can be carefully looked after, it will be found better to start the seedlings in nursery and transplant at one year, than to plant where the trees are to stand, particularly if seedlings are to be depended upon without budding or grafting. These latter operations are less successful with the pecan than with most fruit trees, though they are by no means impossible to accomplish. On seedlings one or two years old annular budding in early summer succeeds best. On trees of larger size, two inches or more in diameter, cleft grafting at the crown, before the buds start in early spring, banking the scions to the top bud with earth, has been found successful. Only such pruning as will keep the trees well balanced is needed. The growth of cultivated crops among the trees will be found advantageous if the fertility is kept up. Only the choicest nuts should be planted, unless for grafting, and seed nuts should be secured from regions where climatic conditions are as nearly identical with the locality as possible. For North Carolina the best varieties will probably be found in South Carolina, Florida, Mississippi and Louisiana. Among them may be named the following:

Faust, a South Carolina variety of medium to large size, medium shell and good quality.

Frotscher, a Louisiana variety of large size, very thin shell and plump kernel of good quality.

Jewett, from Mississippi; a large long nut, rather irregular; shell medium; quality very good.

Ribera, a large variety from Florida.

Stuart, a large, roundish, oblong nut from Mississippi.

Turkey Egg, a variety from Florida; large and thin-shelled.

Van Deman, a large variety from Mississippi, of oblong form and thin shell.

Persian Walnut.

This species (*Juglans regia*), which is quite commonly known under the names English walnut and Madeira nut, has long been experimentally planted in our Eastern States. Occasional trees about the

older cities of the Eastern States succeed so well that there is encouragement for further effort with the improved varieties known to be of superior hardness and productiveness. It should be thoroughly tested in those portions of North Carolina where the combination of good soil, mild climate and freedom from late and early frosts is found—notably in the thermal belts of the southwest portion of the State. In California this nut is largely grown from seed, though it is easily budded and grafted upon seedlings of its own species and upon the native California walnut. It could probably be successfully worked by annular budding on small trees of the black walnut just as the sap is starting in the spring. The varieties which have proved hardiest and most productive thus far are of comparatively recent introduction from France. They are the Chaberte, Franquette, Mayette and Præparturiens, the last named being the best known and most widely disseminated of the type. It is a nut of but medium size, but so precocious and regularly productive as to make up in quantity what the individual nuts lack in size. A few trees of each of these should be planted in every locality where conditions are favorable. It is probable that at least one of the Japanese walnuts (*Juglans sieboldiana*) recently introduced will be found suited to conditions where the Persian walnut succeeds, but it has not as yet been fruited in the eastern United States.

Rational Stock Feeding

INCLUDING

I. DEFINITION OF TERMS, AND COMPOSITION AND DIGESTIBILITY OF FOODS.
II. FEEDING STANDARDS.
III. HOW STOCK RATIONS CAN BE CALCULATED.
IV. SOME RATIONS FED IN NORTH CAROLINA AND SOME RATIONS SUGGESTED.
V. COMMENTS OF PRACTICAL STOCK BREEDERS AND FEEDERS.

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RALEIGH, N. C.

The subject of stock feeding is of such importance that the Experiment Station continues to call attention to it, not only in conducting experiments to determine the digestibility of various common foods in daily use, but also in distributing information designed to be of immediate value to the stock feeder.

There are in North Carolina, according to the latest returns (State Auditor's Report of 1893),

Horses	143,157,	valued at	$7,499,873.
Mules	108,926,	"	6,496,298.
Cattle	634,754,	"	4,954,339.
Hogs	1,118,743,	"	1,498,437.
Sheep and Goats	404,996,	"	401,113.
Total	2,410,576,	"	$20,850,059.

Assuming that the very small sum of fifteen cents per month for each head could be saved by more careful feeding, there would be saved to the people of the State over four millions of dollars annually, a sum approximating nearly one-sixtieth of the total assessed real and personal property of the whole State.

All stock feeds are not the same in quality; some are richer in some ingredients than others. These ingredients when eaten in food act differently in building up the body. Some make flesh, some make bone, some make heat and force. Foods, therefore, vary greatly in value for different purposes. Again, the constituents may not wholly be available to the animal. A portion of a certain constituent may be easily digested, while the other part may pass entirely through and go off as waste. If the manure is not preserved it is really an absolute waste. The digestible portions of the various constituents must be determined by actual feeding tests with animals, while the constituents must be carefully analyzed chemically. By actual feeding it has been ascertained what quantity of these digestible constituents is needed for different purposes of feeding to produce fat, or growth, or sustain vigor when worked. In this way we can lay down a rule for feeding animals, and knowing the foods we have at hand and the digestible proportions, it will be easy to combine them according to the best advantage.

The object of this bulletin is to describe in detail the methods for studying the various foods at hand and ascertain what combinations are best for certain purposes. The importance of the subject is such that a portion of bulletin No. 90 of this Station by B. W. Kilgore, Assistant Chemist, is reprinted in order to present herewith a more complete presentation of the various points bearing upon the subject.

The people of the State in order to make money must save it, and to accomplish this no better way can be suggested for immediate trial than more careful feeding of their stock. To this end a thorough understanding of the principles underlying it is essential. Our people must weigh their stock foods, and mix them in the right proportions if they desire to stop a tremendous leak in farm economy.

H. B. Battle, *Director.*

RATIONAL STOCK FEEDING,

INCLUDING

By F. E. EMERY, Agriculturist, and B. W. KILGORE, Assistant Chemist.

I. DEFINITIONS OF TERMS, AND COMPOSITION AND DIGESTIBILITY OF FOODS.

The value of food materials depends largely upon their composition and digestibility. The former is ascertained by chemical analysis; the latter by actual trials with animals.

Composition of Feeding Stuffs. Nutrients.

By chemical analysis, foods are separated into six classes of substances, viz.:

1. *Water*, which is present in all feeding stuffs. It composes about 80 per cent. of green and succulent fodders, about 90 per cent. of root crops, 75 per cent. of silage, and 10 to 15 per cent. of hays and grains. In these it is present as mechanically adhering or hydroscopic moisture. It is a necessary constituent of the animal body, of which it makes up 40 to 65 per cent. Water is determined by heating the substance for several hours at the temperature of boiling water, at which temperature it passes off as steam.

2. *Ash* is the inorganic, or mineral matter of plants, and is the residue left after burning till all volatile material is driven off. It is composed mainly of soda, potash, lime, and magnesia, in the form of phosphates, sulfates, chlorids, and carbonates. Ash furnishes the materials for the bony structure of animals, and enters to a much less extent into the tissues and organs.

3. *Fats* (*ether extract*) represents whatever is dissolved from foods by dry ether. It is composed mainly of fats and oils, but contains, in addition, quantities of gums, wax and coloring matter, depending upon the substances extracted.

4. *Protein*, the term as used in connection with fodder analyses, includes *Albuminoids* and *Amides*, the albuminoids being the more

Note.—Parts 1, 2, and 3 are reprints from Bulletin 90, with changes and additions.

valuable, and, at the same time, composing by far the larger portion of the protein compounds. They are the nitrogenous compounds of plants and animals, and are determined by estimating the nitrogen in them, which element composes about 16 per cent. of the weight of protein substances. None of the other classes of substances contain nitrogen. They are represented in the animal body by ligaments, lean meat, muscles, tendons, and tissues. *Amides* are unorganized protein, or protein in a transitory stage, and are very abundant in pasture grass and young growing plants, but change largely into organized protein as the plant reaches maturity. Amides are considered of much less nutritive value than albuminoids, and act as protectors or conservers of the latter.

5. *Crude fiber*, or *cellulose*, is the cell wall and structure material of plants, and is usually the most indigestible portion of them, but when digested is considered of equal value to starch and sugar. The lint of cotton is almost pure cellulose. Its composition is similar to that of starch. It is determined by boiling the food-stuff with weak acid and alkali, thus dissolving all other constituents. *Crude fiber* and *nitrogen-free extract* taken together are known as *carbohydrates.*

6. *Nitrogen-free extract* is the term applied to those non-nitrogenous constituents of foods which are represented in the main by sugars, starch, dextrin, and gums. They all contain carbon, hydrogen, and oxygen, but no nitrogen, as does protein. Nitrogen-free extract is estimated by difference, it being equal to the difference between the sum of the above five constituents, water, ash, protein, fats, and crude fiber, and 100. It is, perhaps, the most inaccurate of all the determinations in a food analysis, inasmuch as all the errors and differences in the other determinations fall upon it. It seems very desirable that some of the constituents, at least, of the nitrogen-free extract should be determined directly. This is already being done to a limited extent. Some preliminary work has been done in this laboratory in that line, and the study will be carried on.

Dry matter and Organic matter. Neither of these terms represent a single class of constituents, or nutrients. Dry matter is what is left of a plant, or food-stuff, after the water is driven off or subtracted, and organic matter is dry matter minus the ash, for example: if the original food-stuff as fed is represented as 100 per cent., and it contains 10 per cent. of water and 5 per cent. of ash, then dry matter is equal to 100 per cent., less 10 per cent. water, or 90 per cent., and organic matter is 90 per cent. dry matter less 5 per cent. ash, or 85 per cent.

To enable those not familiar with the subject to gain a clear idea of the parts of a food-stuffs, and the terms representing them as used in fodder analyses, the following statement is presented:

Food-stuff. { Water. / Dry matter. { Ash. / Organic matter. { Protein. / Fats. / Carbohydrates. { Nitrogen-free ex't. / Crude fiber.

Nutrients. Protein, fats, carbohydrates, nitrogen-free extract and crude fiber and mineral matter are called nutrients, because of their functions in animal nutrition. Nitrogen-free extract and crude fiber are included together under the one name of carbohydrates, because they are all compounds of carbon, hydrogen, and oxygen, and the digestible portion of each is considered of equal value and perform the same offices in animal nutrition. Familiar examples of the four classes of nutrients are presented below. Water is omitted because it is the same, whether taken in food or drink, and we do not feed a fodder for the sake of the water it contains:

Protein.	Albumen (white of egg), washed lean meat, casein, or curd of milk, gluten of flour, fibrin of blood, gelatin, glue, etc.
Fats.	Cotton-seed oil, linseed oil, olive oil, corn oil, wheat oil, oat oil; the fat of milk (butter), the fat of meat (hog lard), mutton (mutton suet), beef (tallow), fish oil, etc.
Carbohydrates.	Sugars (cane sugar, milk sugar, and glucose), starch, dextrin, gums, woody fiber, etc.
Mineral matter.	Sodium chlorid (common salt), phosphates of lime and soda, etc.

Functions of Nutrients.

Having defined the classes of nutrients as they occur in foods, it is of interest now to state the offices performed by them in animal nutrition.

Water is not a nutrient in the sense in which the term is here used, though the animal body cannot be supported without it.

The ash, or mineral matter, furnishes the material for the bony structure of the body, and, to a far less extent, of the soft tissues. Most of our foods and rations contain an abundant supply of the mineral elements, so little or no notice need be taken of them in feeding.

Protein differs from all the other nutrients in containing the element nitrogen, and is the producer of flesh, ligaments, muscles, tendons, sinews, hair, hide, and all portions of the animal machine which has strength, except the bones. The protein bodies are of the utmost importance in the animal structure. They compose the larger part of the animal machinery, and are the exclusive source of its repair as occasioned by the continuous wear and tear of the system, due to the internal and external movements of the body; they are the basis of blood, and the source of casein in milk; and in the absence of sufficient quantities of fats and carbohydrates in the food for the production of heat and energy, they are transformed into fats, and perform the office of fats in nutrition. This latter transformation may also result from an excess of protein. The heat-producing power of protein is but little different from that of

carbohydrates; the amount of fat it produces is probably much less, while as a heat-producer, fat is worth about 2.25 times as much as protein. These facts, combined with the high cost of protein in foods, renders it usually uneconomical to feed protein for the production of fat to be either stored in the body as such, or to be used as fuel, since the fats and and carbohydrates perform these offices, and cost much less. It is to be remembered that the protein bodies are the "flesh formers," and though they can perform the offices of fats and carbohydrates in nutrition, fats and carbohydrates cannot take the place of protein.

Fats and carbohydrates perform the same offices in the body—those of the production of heat to keep the body warm, and the force by which the animal mechanism is run. They are the "heat and force producers," and are consumed in the body as fuel, giving out heat, muscular, and intellectual energy. For the production of heat and energy one pound of fat is worth about 2.25 times as much as a pound of carbohydrates. Fats give out about 2.25 times the heat that carbohydrates do. Besides serving as heat and force producers, carbohydrates are converted in the animal body into fats, and, together with the fats of the food, are stored as such in fatty tissue. The value of carbohydrates for the production of fats is supposed to be in about the same proportion as the heat-producing powers of carbohydrates to fats.

Carbohydrates are not found in the animal body as such, but are converted into fats. There are, therefore, only four classes of substances composing the animal body, viz.: water, ash, fats, and protein.

The main and distinctive offices of the nutrients of foods are: Ash, or mineral constituents, are bone-producers; the protein bodies are the flesh-formers; and fats and carbohydrates are the heat and force producers. The nutrients already located in the animal body perform the same offices as the corresponding ones of foods. In case of a deficiency of nutrients in foods given, the fats, or protein and fats, are drawn upon to assist in running the animal machine. Carbohydrates and fats, in being consumed, prevent the consumption of protein, but so soon as they become insufficient to supply the necessary heat and force for the body, protein substances, in the form of lean meat, muscle, etc., are drawn upon. A sufficient supply of carbohydrates and fats is, therefore, necessary to the protection of the animal frame-work. The following is a statement of the

Functions of Food in the Animal Body.

Food nourishes and supports the body

By supplying—

1. The materials of which it is made.
2. The materials to repair its waste and wear.

By producing—

3. Heat to keep it warm.
4. Force and energy for muscular and other work.

These offices are performed by the nutrients:

Protein	Which is the basis of blood, lean meat, tendons, ligaments, sinews, hair, skin, etc.—
	Is converted into fats.
	Is used as fuel for heat and force.
Fats	Are used as fuel for heat and force.
	Are stored in the fatty tissue of the body.
Carbohydrates (Nitrogen-free extract and crude fiber).	Are converted into fats and stored in the body, or
	Are used as fuel for heat and force.
Mineral matter	Forms bone and a very small part of muscular and fatty tissues.

The Digestibility of Feeding Stuffs.

As was stated in the beginning the value of feeding stuffs depends upon their composition and digestibility. The element of composition has been discussed; next will be considered the digestibility.

All the food eaten by an animal is not digested and used in nutrition, but only that portion which is dissolved by the alimentary agents and taken into the circulation of the system, the portion which is assimilated. The residue, or undigested portion, forms the solid excrement of the animal.

The digestibility of a considerable number of American cattle foods have already been determined. This is done by feeding a uniform and weighed quantity of food of known composition for sufficient length of time to eliminate all residues of previously fed fodders, then collecting the dung for a number of days, usually five or six, weigh and analyze. The dung contains the undigested food residue, and the difference between this and the total food consumed gives the portion digested. Thus, two foods having the same composition, their values would be determined by the amounts of nutrients digested from each.

Average Composition and Digestible Nutrients in Feeding Stuffs.

In table I is presented the composition, most of them averages of quite a number of analyses, of American feeding stuffs of most interest in North Carolina. The composition, especially of coarse fodders, is affected by so many conditions, as soil, climate, season, cultivation, harvesting, handling, stage of maturity, etc., that the greater the number of good analyses entering into an average the nearer may the average be expected to represent the general composition.

The analyses of the feeding stuffs shown in the table represent their composition as they are usually fed to animals. In addition

TABLE I.—Showing Average Composition of Feeding Stuffs—American Analyses.

Foods.	No. of analyses.	Percentage composition.							Percentage of digestible matter.					
		Water.	Dry matter.	Total protein.	Fats (Eth. extract.)	N.-free ex't.	Crude fiber.	Ash.	Dry matter.	Protein.	Fats.	N.-free ex't.	Crude fiber.	Ash.
Cowpea-vine hay	13	11.90	88.10	14.43	2.49	41.22	21.54	8.42	52.15	9.31	1.24	29.14	9.24	3.79
Crimson clover hay	2	10.85	89.15	15.20	1.84	38.91	25.65	7.73	55.45	10.50	.89	28.82	12.49	4.14
Lucerne, or Alfalfa hay	3	11.53	88.47	14 89	2.24	34.18	30.26	6.90	52.55	10.85	1.15	23.21	13.95	-----
Red clover hay	35	11.63	88.37	12 50	2.43	40.43	26.81	6.15	45.69	6.17	1.03	23.28	12.73	-----
Alsike clover hay	6	8.91	91.09	13.18	2.56	40.48	27 22	7.63	50.00	7.31	1.36	25.95	12.57	-----
Soy (soja) bean silage	1	74.20	25.80	4.05	2.23	6.95	9.70	2.84	15.22	3.07	1.60	3.61	5.31	1.61
Soy bean hay	3	12.04	87.96	15.98	4.19	34.39	27.57	5.83	54.89	11.27	1.74	25.93	16.38	1.38
Peanut-vine hay	2	8.34	91.66	10.31	4.52	46.64	23.14	7.05	54.90	6.53	2.98	32.41	12.01	1.44
Corn silage, whole plant	3	71.98	28 02	2.11	.61	16.42	7.72	1.16	14 91	.73	.40	9.93	3.34	0.30
Pulled fodder, blades alone	2	8 94	91.06	11.82	3.31	41 45	24.72	9.72	54.64	5.34	1.96	26.28	17.06	2.56
Corn fodder, whole plant	11	32.19	67.81	4 81	1.28	37.15	20.21	4 32	-----	2.60	.90	23.63	13.84	-----
Corn stover, whole plant, minus ears	10	22.81	77.19	5.47	1.34	39.90	25.55	4.92	47.70	2 80	.69	25.29	17.04	2.18
Corn butts or stubble, portion below ears*	1	46.74	53.26	1.76	1.08	27.37	20.46	2.59	35.42	.37	.86	18.89	15.04	.30
Corn husks or shucks*	1	8.10	91.90	3.33	0.85	51.55	32.81	3.36	66 17	.98	.28	38.65	26.08	.54
Corn tops, cut above ears	2	12.19	87.81	7.96	2.44	42.16	28.03	7.22	50.32	3.08	1.62	24.37	19.87	.54
Sorghum fodder, leaves alone	1	12.43	87.57	9.60	4.55	44.93	23.93	4.56	55.25	5.84	2.12	28.98	16.84	1.34
Sorghum bagasse	2	11.25	88.75	3.44	1.44	50.47	30.52	2.88	53.78	.47	.67	32.72	19.46	.38
Timothy hay	58	10.21	89.79	6.18	2.19	46.91	30.29	4.22	51.90	3.03	1.21	30.16	16.14	1.46
Red top hay (Agrostis vulgaris)	4	9.52	90.48	7.70	2.14	46.19	28.52	5.93	52.12	4.65	.94	27.30	17.45	1.44
Orchard grass hay	6	9 80	90.20	6.82	2.38	42.12	33.23	5 63	51.68	4.08	1.29	23.42	20.40	1.95
Johnson grass hay	3	12.30	87.70	7.55	2.93	41.62	29.69	5.91	47.80	3.37	1.16	22.64	17.16	3.32
Cattail, or pearl millet	2	10.47	89.53	9.94	1.97	36.62	30.78	10.22	55.78	6.22	.91	21.64	20.47	6.99
Mixed hays	10	15.41	84 59	6.25	2.09	40.30	31.21	4.73	45.93	2.99	1.04	22.93	14.95	-----
Meadow (mixed) hay (horse)	Same composition as above								40.11	3.60	.37	23.42	12.18	-----

*Analyses from Bulletin 20, Maryland Experiment Station.

TABLE I.—Showing Average Composition of Feeding Stuffs—American Analyses.—*Continued.*

Foods.	No. of analyses.	Percentage composition.							Percentage of digestible matter.					
		Water.	Dry matter.	Total protein.	Fats (Eth. extract.)	N.-free ex't.	Crude fiber.	Ash.	Dry matter.	Protein.	Fats.	N.-free ex't.	Crude fiber.	Ash.
Oat straw	13	8.84	91.16	3.80	2.29	39.12	41.23	4 72	45.85	?	.88	20.81	23.75	.....
Whole raw cotton-seed	1	17.51	82.49	14.48	19.38	25.41	20.30	2.90	54.53	9.83	16.88	12.60	15.32	1.25
Whole roasted cotton-seed	1	9.32	90.68	16.09	22.48	25.78	24.03	2.26	50 69	7.56	16.11	13.25	15.84	.....
Cotton-seed meal	4	7.74	92.26	38.78	10.25	30 20	6.37	6.66	67.63	34.05	9.19	18.57	2.96	2.10
Cotton-seed hulls	5	11.50	88.50	4.15	2.92	39.14	39.87	2.38	36.37	.24	2.32	13.42	18.90	.51
Wheat bran	70	12.43	87.57	15 37	3.85	53.44	9.32	5.60	51.92	11.97	2.82	35 16	1.68	.....
Corn meal (cows)	63	15.61	84.39	9.12	3.93	67.92	1.99	1.45	71.39	5.32	3.61	59.16	0	.....
Corn meal (pigs)	Same composition as for cows.								75.53	7.85	3.21	63.93	.58	.....
Corn (digested by horse)	Same composition as for cows.								78.01	8.09	3.32	64 89	0.84	.....
Corn meal (digested by goats)	Same composition as for cows.								71.39	5.32	3.61	59.16	.....	.....
Whole corn (pigs)	201	10.52	89.48	10 59	5.44	69.81	2.09	1.55	77.04	8.40	3.62	63.74	.91	.....
Corn and cob meal (goats)	9	14.52	85.48	8.36	3.51	65.03	7.06	1.52	67.27	5 45	2.97	55.67	3.37	.....
Corn and cob meal (pigs)	Same composition as for goats.								64.62	6.33	2.88	54.37	2.01	.....
Oats‡	25	10.94	89.06	11.38	4.81	60.05	9.85	2.97	.....	8.76	3.94	44.44	1.67	.....
Oats (horse)	Same composition								59.71	9.05	3.42	45 08	2.87	.....
Rice bran, or danse (sheep)	5	9.65	90.35	12.07	8.76	50.04	9.51	9.97	80.63	9.33	7.82	50.04	6 39	.....
Cowpea, a bean, ground (horse)	5	14.81	85.19	20.75	1.44	55.72	4 06	3.22	74.16	17.82	0.19	52.13	2.66	.....
Cowpea, a bean, ground (ruminants)	Same composition as for horse.								75.72	18.27	1.17	51.09	2.91	.....
Cowpea, ground (swine)	Same composition as for horse.								77.48	18.28	.70	53 86	2.77	.....
Soy beans (sheep)	8	10.80	89.20	33.98	16 85	28.89	4.79	4.69	75.86	29.64	15.88	17.96	.....	
Rye bran (swine)	12	11.64	88.36	14.74	2.81	63.74	3.48	3.59	59.20	9.72	1.61	47.47	.31	.....
Rice (swine)	10	12.44	87.56	7.44	0.19	79.20	0.35	0.38	86 07	6.38	.13	78.88	.....	.....
Potatoes (swine)	12	78.89	21.71	2.14	0.10	17.36	0.56	0.95	19.62	1.55	.....	17.02	.30	.....
Buttermilk	1	91.49	8.51	3.19	0.27	4.49	.....	0.56	8.05	3.05	.25	4.42	.....	.....
Carrots (horse)	15	88.59	11.41	1.14	0 42	7.56	1.27	1.02	9.95	1.13	.....	7.09	.....	.....
Cow's milk, composite (calves)	...	85.26	14.74	3.21	5.37	5.44	.....	0.72	14.41	3.09	5.36	5.34	.....	.....

‡Compilation of Dr. E. H. Jenkins, Annual Report Connecticut Experiment Station, 1888.

TABLE II. COEFFICIENTS OF DIGESTIBILITY OF FEEDING STUFFS.

FOODS.	Dry matter.	Total protein.	Fats.	Nitrogen-free extract.	Crude fiber.	Ash.	AUTHORITY.
Cowpea-vine hay	59.2	64.5	50 0	70.7	42.9	45.1	N. C. Expt. Sta., Bulletin 87D.
Crimson clover hay	62.2	69.1	48.8	71.5	48.7	53.6	N. C. Expt. Sta., Bulletin 87D.
Lucerne, or alfalfa hay	59.4	72.9	51.2	67.9	46.1	....	N. Y. State Expt. Sta. and O'Brine.
Red clover hay	51.7	49.4	42.6	57 6	47.5	....	Armsby.
Alsike clover hay	54.9	55.5	53.2	64.1	46.2	....	Maine Expt. Sta., 1886–'87.
Peanut-vine hay	59.9	63.3	65 9	69.5	51.9	20.4	N. C. Expt. Sta., Bulletin 97.
Soy (soja) bean silage	59.0	75.8	71.9	52.0	54.8	56.7	N. C. Expt. Sta., Bulletin 87D.
Soy (soja) bean hay	62.4	70.5	41.6	75.4	59.4	23 7	N. C. Expt. Sta., Bulletin 97 and Sturtevant.
Corn silage, whole plant	53.2	34.4	66 0	60.5	43.2	26.9	N. C. Expt. Sta., Bulletin 87D.
Pulled fodder, blades alone	60.0	45.2	59.2	63 4	69.1	26.2	Maryland Expt. Sta. Bul. 20, and N. C. Sta. Bul. 87D.
Corn fodder, whole plant	....	54.0	70.6	63.6	68.5	....	Sturtevant, Woll, and Penn. Sta.*
Corn stover, whole plant, minus ears	61.8	51.3	51.9	63.4	66.7	44.4	Armsby.
Crushed corn butts or stubble, portion below ear	66.5	21.0	79.5	69.0	73.5	11.5	Maryland Expt. Sta., Bulletin 20, p. 12.
Corn husks, or shucks	72.0	29.5	32.5	75.0	79.5	16.0	Maryland Expt. Sta., Bulletin 20, p. 12.
Corn tops, cut above ears	57.3	38 7	67.3	57.8	70.9	7 5	Texas Sta., Bul. 15, and Maryland Sta., Bul. 20.
Sorghum fodder, leaves alone	63.1	60.8	46.7	64.5	70.4	29.5	N. C. Expt. Sta., Bulletin 97.
Sorghum bagasse	60 6	13.7	46.4	64.8	63.8	13.4	N. C. Expt. Sta., Bulletin 97.
Timothy hay	57.8	49.1	55 5	64.3	53.3	34.6	Maine Expt. Sta., Ann. Rep., 1888–'91, av. 6 determ.
Red-top hay	57.6	60.4	44.2	59.1	61.2	24 3	Maine Expt. Sta., Ann. Rep., 1888 p. 96.
Orchard-grass hay	57.3	59.8	54.6	55.6	61.4	35.0	Me. and N. Y. Expt. Stas., Ann. Reps., 1888, and 8th.
Johnson grass hay	54.5	44.7	39.5	54.4	57.8	56.1	N. C. Expt. Sta., Bulletin 97.
Cat-tail, or pearl millet	62.3	62.6	46.1	59.1	66.5	68.4	N. C. Expt. Sta., Bulletin 97.
Mixed hays	54.3	47.9	50.0	56.9	47.9	....	N. Y. Expt. Sta., and Sturtevant. 8th Ann. Rep., p. 95.
Oat straw	50.3	?	38.3	53.2	57.6	....	Maine Expt. Sta., Ann. Rep., 1886–'87, p. 76.
Whole raw cotton seed	66.1	67 9	87.1	49.6	75.5	43.3	N. C. Expt. Sta., Bulletin 87D.

*Average of Sturtevant, Woll, and Dent fodder, ears glazing; Burrill and Whitman fodder, nubbins glazing; and Burrill and Whitman fodder, by Pennsylvania Station, Annual Report 1890, p. 62.

TABLE II. COEFFICIENTS OF DIGESTIBILITY OF FEEDING STUFFS.—*Continued.*

FOODS.	Dry matter.	Total protein.	Fats.	Nitrogen-free extract.	Crude fiber.	Ash.	AUTHORITY.
Whole roasted cotton seed	55.9	47.0	71.7	51.4	65.9	....	N. C. Expt. Sta., Bulletin 87D.
Cotton-seed meal	73.3	87.8	89.7	61.5	46.4	31.5	N. C. Expt. Sta., Bulletin 97, and Armsby and Wolff.
Cotton-seed hulls	41.1	5.9	79.4	34.3	47.4	21.4	Texas and N. C. Stations.
Wheat bran	59 3	77.9	73.3	65.8	18.0	....	Me. Expt. Sta., Ann. Repts. 1889 and 1891, pp. 61, 39.
Corn meal (cows)	84 6	58 3	91.9	87.1	0	....	N. Y. Expt. Sta., 7th Ann. Rep., p. 279.
Corn meal (goats)	86 9	66.9	80.5	94.2	....	....	N. C. Expt. Sta., Bulletin 97.
Corn meal (pigs)	89.5	86.1	81.7	94.2	29.4	....	Maine Expt. Sta., Rept. 1885–'86, p. 61.
Whole corn (pigs)	86.1	79.3	66.6	91.3	43 5	....	Maine and Minn. Expt. Stas., Rept. '85–'6, and Bul. 26.
Corn-and-cob meal (pigs)	75.6	75.7	82 0	83.6	28.5	....	Maine Expt. Sta., Rep. 1885–'86, p. 62.
Corn-and-cob meal (goats)	78.7	65.2	84.6	85.6	47.7	....	N. C. Expt. Sta., Bulletin 97.
Oats	....	77.0	82.0	74.0	17.0	....	German Experiments.
Oats (horse)**	69.36	79.51	71.13	75.08	29.13	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1216.
Corn (horse)**	88.72	76.42	61.03	92.11	40.46	....	Ger. Ex , Zusam. u. Verd. der Futtermittel, p. 1216.
Sour milk, clabbered (swine)**	94.6	95.7	95.0	98.5	.....	....	Zusammen Setzung und Verd. der Futtermittel von
Cow's milk (calves)**	97.88	96.4	99.8	98 2	....	....	Dr. Th. Dietrich and Dr. J. König.
Rice bran, or douse (sheep)	89 25	77.33	89.31	100.08	67.29	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1118.
Meadow (mixed) hay (horse)	50.22	57.54	18.00	58 12	39 02	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1216.
Field beans, ground (horse)	87.07	85.89	13.20	93.55	65 40	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1111.
Field beans (ground) ruminants	88.88	88 05	81.51	91.69	71.89	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1214.
Potatoes, solanum tubers (swine)	92.96	72.54	....	98.05	55.11	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1216.
Pease, ground	90.95	88.10	49.22	96.66	68.39	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1216.
Rye bean	67.00	65.96	57.53	74.48	9.01	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1216.
Rice	98.30	85.80	70.10	99.60	.....	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1110.
Soy beans (sheep)	85.05	87.22	94.28	62.18	.....	....	Ger. Ex., Zusam. u. Verd. der Futtermittel, p. 1113.

**Organic substance.

to the chemical composition of the foods obtained by analysis, is presented, also, the percentages of digestible nutrients in each, calculated from the percentage composition of the foods in the table by multiplying by the *coefficients of digestibility* of each food and nutrient contained in table II, which follows.

Coefficients of Digestibility

Are the proportions of the different nutrients digested, and are obtained by dividing the total amount of each nutrient consumed by the amount digested. In Table II are brought together the coefficients of digestibility of all the fodders, the compositions of which are presented in Table I. These are mainly the results of American experiments.

Amount of Digestible Matter in Feeding Stuffs.

In table I is given the average composition of foods, and in table II their digestibility. By combining the data of these two tables the per cents. of digestible matter of the same foods, also shown in table I, are obtained in the following way:

	Cowpea-vine hay contains per cent., or pounds in 100 of (see Table I).		Coefficients of digestibility of cowpea-vine hay (see Table II).		Per cent., or lbs of digestible matter in 100 of cowpea-vine hay.
Dry matter	88.10	×	59.2	=	52.15
Protein	14.43	×	64.5	=	9.31
Fats	2.49	×	50.0	=	1.24
Nitrogen-free extract	41.22	×	70.7	=	29.14
Crude fiber	21.54	×	42.9	=	9.24
Ash	8.42	×	45.1	=	3.79

They may be regarded as representing, as well as per cent., the number of pounds of digestible nutrients in 100 pounds of the various foods in the condition in which they are fed, and are the amounts of these foods used by animals in the support of their bodies.

From this table of percentage of digestible matter in foods, it is easy to ascertain the amounts of digestible nutrients eaten per day by the animals we may be feeding. We only need to multiply the number of pounds of the food or foods eaten by the per cent. of digestible nutrients in them. Say a cow is eating 20 pounds cowpea-vine hay per day, then the amounts of digestible nutrients consumed are found as follows:

	Per cent. of digestible matter in cowpea-vine hay.		No. lbs hay eaten.		Lbs of digestible matter eaten.
Dry matter	52.15	×	20	=	10.43
Protein	9.31	×	20	=	1.86
Fats	1.24	×	20	=	.25
Nitrogen-free extract	29.14	×	20	=	5.82
Crude fiber	9.24	×	20	=	1.85
Ash	3.79	×	20	=	.76

The amount of digestible matter eaten by any animal may be obtained in a similar way. Where two foods are fed in a ration each will have to be operated upon separately, and their sums taken for the total digestible nutrients consumed.

To save the feeder the time and trouble of making these calculations, the amounts of digestible dry matter and nutrients in 1, 2, 3, 4, 5, 10, and 2,000 pounds of the coarse fodders, grains, seeds, and by-products, whose composition and digestibility are presented in tables I and II, have been carefully calculated, and are given in table III. The nitrogen-free extract and crude fiber have been combined in this table under the one name of carbohydrates, because the digestible portion of each is considered of equal value, and they perform the same offices in animal nutrition. The ash is also omitted, for the reason given in the first part of this bulletin. This table must not be supposed to give the absolute amounts of digestible nutrients contained in all the qualities of these various foods, for no two of the same kind are likely to have exactly the same composition, and may differ very widely, nor are any two animals, even of the same kind, likely to possess the same digestive capacity and power of assimilating foods. Even with these unavoidable defects the knowledge thus ascertained can be put to practical use, and, in connection with the Feeding Standards, soon to be described, stock can be fed far more intelligently, safely, and economically.

The digestible nutrients have been calculated for the most convenient numbers only, but by combining these and adding the corresponding nutrients, the amounts of digestible nutrients can be easily obtained for any quantity of food that is likely to be fed under ordinary circumstances. Thus, suppose we desire to know the pounds of nutrients in 15 pounds of any of the foods, we have merely to add the nutrients corresponding to the 10 and 5 pound weights; for 19 add those for 10, 5, and 4, and so on for any number up to 20, which may be obtained by moving the decimal point two places to the left in the line for 2,000 pounds. For numbers larger than 20, multiples may be used, as for 40 take four times the nutrients for 10.

The nutrients in 2,000 pounds of each of the foods were inserted in this table to enable comparison of the digestible nutrients in one ton of the different foods. The chief value of table III will be found in the compounding of rations, and it will receive further consideration under that head.

TABLE III. SHOWING AMOUNT OF DIGESTIBLE DRY MATTER AND NUTRIENTS IN 1, 2, 3, 4, 5, 10, AND 2,000 POUNDS OF FEEDING STUFFS.

FOODS.	Weight. Lbs.	Dry matter. Lbs.	Total Protein. Lbs.	Carbo-hydrates. Lbs.	Fats. Lbs.
Cowpea-vine hay	1	.5215	.093	.3838	.0124
	2	1.043	.186	.767	.024
	3	1.564	.279	1.151	.037
	4	2.086	.372	1.535	.049
	5	2.607	.465	1.919	.062
	10	5.215	.931	3.838	.124
	2,000	1,043.00	186.20	767.60	24.80
Crimson clover hay	1	.5545	.1050	.4131	.00898
	2	1.109	.210	.826	.018
	3	1.663	.315	1.239	.027
	4	2.218	.420	1.652	.036
	5	2.772	.525	2.065	.045
	10	5.545	1.050	4.131	.089
	2,000	1,109.00	210.00	826.20	17.96
Lucerne, or alfalfa hay	1	.5254	.1085	.3716	.0115
	2	1.050	.217	.743	.023
	3	1.576	.325	1.114	.034
	4	2.101	.434	1.486	.046
	5	2.627	.542	1.858	.057
	10	5.254	1.085	3.716	.115
	2,000	1,050.80	217.00	743.20	23.00
Red clover hay	1	.4569	.0617	.3602	.0103
	2	.913	.123	.720	.020
	3	1.370	.185	1.080	.030
	4	1.827	.246	1.440	.041
	5	2.284	.308	1.801	.051
	10	4.569	.617	3.602	.103
	2,000	913.80	123.40	720.40	20.60
Alsike clover hay	1	.5000	.073	.3852	.0136
	2	1.000	.146	.770	.027
	3	1.500	.219	1.155	.040
	4	2.000	.292	1.540	.054
	5	2.500	.365	1.926	.068
	10	5.000	.731	3 852	.136
	2,000	1,000.00	146.20	770.40	27.20
Soy (soja) beans (sheep)	1	.7586	.2964	.17964	.15886
	2	1.517	.593	.3593	.3177
	3	2.276	.889	.5389	.4766
	4	3.034	1.186	.7186	.6354
	5	3.793	1.482	.8982	.7943
	10	7.586	2.964	1.796	1.588
	2,000	1,517.2	592.8	359.28	317.72
Soy bean hay	1	.5489	.1127	.4231	.0174
	2	1.097	.225	.846	.034
	3	1.646	.338	1.269	.052
	4	2.195	.450	1.692	.069
	5	2.744	.563	2.115	.087
	10	5.48	1.12	4.23	.174
	2,000	1,097.80	225.40	846.20	34.80
Soy (soja) bean silage	1	.1522	.03069	.08930	.0159
	2	.304	.061	.178	.031
	3	.456	.092	.267	.047
	4	.608	.122	.357	.063
	5	.761	.153	.446	.079
	10	1.522	.306	.893	.159
	2,000	304.40	61.38	178.60	31.80

TABLE III. Showing Amount of Digestible Dry Matter and Nutrients in 1, 2, 3, 4, 5, 10, and 2,000 Pounds of Feeding Stuffs.—*Continued.*

Foods.	Weight. Lbs.	Dry Matter. Lbs.	Total Protein. Lbs.	Carbo-hydrates. Lbs.	Fats. Lbs.
Peanut-vine hay	1	.5490	.0653	.4442	.0298
	2	1.098	.130	.888	.059
	3	1.647	.195	1.332	.089
	4	2 196	.261	1.776	.119
	5	2.745	.326	2.221	.149
	10	5.490	.653	4.442	.298
	2,000	1,098.00	130.60	888.40	59.60
Corn fodder (whole plant)	1	------	.0260	.3747	.00903
	2	------	.052	.749	.018
	3	------	.078	1.124	.027
	4	------	.104	1.498	.036
	5	------	.130	1.873	.045
	10	------	.260	3.747	.090
	2,000	------	52.00	749.40	18.06
Corn stover (whole plant, minus ears)	1	.4770	.02806	.4233	.0069
	2	.954	.054	.846	.013
	3	1.431	.084	1.269	.020
	4	1.908	.112	1.693	.027
	5	2.385	.140	2.116	.034
	10	4.770	.280	4.233	.069
	2,000	954.00	56.12	846.60	13.80
Corn tops, cut above ears	1	.5032	.0308	.4424	.0162
	2	1.006	.061	.884	.032
	3	1.509	.092	1.327	.048
	4	2.012	.123	1.769	.064
	5	2.516	.154	2.212	.081
	10	5.03	.308	4.42	.16
	2,000	1,006.40	61.60	884.80	32.40
Corn butts or stubble, portion below ears.	1	.3542	.0037	.3393	.0086
	2	.708	.007	.678	.017
	3	1.062	.011	1.017	.025
	4	1.416	.014	1.357	.034
	5	1.771	.018	1.696	.043
	10	3.542	.037	3.393	.086
	2,000	708.40	7.40	678 60	17.20
Corn husks or shucks	1	.6617	.0098	.6473	.0028
	2	1.323	.019	1.294	.005
	3	1.985	.029	1.941	.008
	4	2.646	.039	2.589	.011
	5	3.308	.049	3.236	.014
	10	6.617	.098	6.47	.028
	2,000	1,323.40	19.60	1,294.60	5.60
Pulled fodder, blades alone	1	.5464	.0534	.4334	.0196
	2	1.092	.106	.866	.039
	3	1.639	.160	1.300	.058
	4	2.185	.213	1.733	.078
	5	2.732	.267	2.167	.098
	10	5.464	.534	4.334	.196
	2,000	1,092.80	106.80	866.80	39.20
Corn silage, whole plant	1	.1491	.00726	.1328	.0040
	2	.298	.014	.265	.008
	3	.447	.021	.398	.012
	4	.596	.029	.531	.016
	5	.745	.036	.664	.020
	10	1.491	.072	1.328	.040
	2,000	298.20	14.52	265.60	8.00

TABLE III. SHOWING AMOUNT OF DIGESTIBLE DRY MATTER AND NUTRIENTS IN 1, 2, 3, 4, 5, 10, AND 2,000 POUNDS OF FEEDING STUFFS.—*Continued.*

FOODS.	Weight. Lbs.	Dry matter. Lbs.	Total protein. Lbs.	Carbo-hydrates. Lbs.	Fats. Lbs.
Timothy hay	1	.5190	.0303	.4630	.0121
	2	1.038	.060	.926	.024
	3	1.557	.090	1.389	.036
	4	2.076	.121	1.852	.048
	5	2.595	.151	2.315	.060
	10	5.190	.303	4.630	.121
	2,000	1 038.00	60.60	926.00	24.20
Red-top hay (Agrostis vulgaris)	1	.5212	.0465	.4475	.0094
	2	1.042	.093	.895	.018
	3	1.563	.139	1.342	.028
	4	2.084	.186	1.790	.037
	5	2.606	.232	2.237	.047
	10	5.212	.465	4.475	.094
	2,000	1,042.40	93.00	895.00	18.80
Orchard grass hay	1	.516	.0408	.4382	.0129
	2	1.033	.081	.876	.025
	3	1.550	.122	1.314	.038
	4	2.067	.163	1.752	.051
	5	2.584	.204	2.191	.064
	10	5.168	.408	4.382	.129
	2,000	1,033.60	81.60	876.40	25.8
Johnson grass hay	1	.4780	.0337	.3980	.0116
	2	.956	.067	.796	.023
	3	1.434	.101	1.194	.034
	4	1.912	.134	1.592	.046
	5	2.39	.168	1.990	.058
	10	4.780	.337	3.980	.116
	2,000	956.00	67.40	796.00	23.20
Mixed hays	1	.4593	.0299	.3788	.0104
	2	.918	.059	.757	.020
	3	1.377	.089	1.136	.031
	4	1.837	.119	1.515	.041
	5	2.296	.149	1.894	.052
	10	4.59	.299	3.788	.104
	2,000	918.60	59.80	757.60	20.80
Mixed hays (horse)	1	.4011	.036	.356	.00376
	2	.802	.072	.712	.007
	3	1.203	.108	1.068	.011
	4	1.604	0.144	1.424	.015
	5	2.005	.180	1.780	.018
	10	4.011	.360	3.560	.037
	2,000	802.20	72.00	712.00	7.520
Cattail, or pearl millet	1	.5578	.0622	.4211	.0091
	2	1.115	.124	.842	.018
	3	1.673	.186	1.263	.027
	4	2.231	.248	1.684	.036
	5	2.789	.311	2.105	.045
	10	5.578	.622	4.211	.091
	2,000	1,115.60	124.40	842.20	18.20
Sorghum fodder (leaves only)	1	.5525	.0584	.4582	.0212
	2	1.105	.116	.906	.042
	3	1.657	.175	1.364	.063
	4	2.210	.233	1.832	.084
	5	2.762	.292	2.291	.106
	10	5.525	.584	4.783	.212
	2,000	1,105.00	116.80	956.60	42.40

TABLE III. Showing Amount of Digestible Dry Matter and Nutrients in 1, 2, 3, 4, 5, 10, and 2,000 Pounds of Feeding Stuffs.—*Continued.*

Foods.	Weight. Lbs.	Dry matter. Lbs.	Total protein. Lbs.	Carbo-hydrates. Lbs.	Fats. Lbs.
Sorghum bagasse	1	.5378	.0047	.5218	.0067
	2	1.075	.009	1.043	.013
	3	1.613	.014	1.565	.020
	4	2.151	.018	2.087	.026
	5	2.689	.023	2.609	.033
	10	5.378	.047	5.218	.067
	2,000	1,075.60	9 40	1,043.60	13.40
Rice bran (sheep)	1	.8063	.0933	.5643	.0782
	2	1.612	.186	1.128	.156
	3	2.419	.280	1.693	.234
	4	3.225	.373	2.257	.313
	5	4.031	.466	2.822	.391
	10	8.064	.933	5.644	.782
	2,000	1,612.74	186.68	1,128.78	156.48
Oat straw	1	.4585	?	.4456	.0088
	2	.917	?	.891	.017
	3	1.375	?	1.336	.026
	4	1.834	?	1.782	.035
	5	2.292	?	2.228	.044
	10	4.585	?	4.456	.088
	2,000	917.00	?	891.20	17.60
Whole raw cotton seed	1	.5453	.0983	.2792	.1688
	2	1.090	.196	.558	.337
	3	1.635	.294	.837	.506
	4	2.181	.393	1.116	.675
	5	2.726	.491	1.396	.844
	10	5.453	.983	2.792	1.688
	2,000	1,090.60	196.60	558.40	337.60
Whole roasted cotton seed	1	.5069	.0756	.2909	.1611
	2	1.013	.151	.581	.322
	3	1.520	.226	.872	.483
	4	2.027	.302	1.163	.644
	5	2.534	.378	1.454	.805
	10	5.069	.756	2.909	1.611
	2,000	1,013.80	151.20	581.80	322.20
Cotton-seed meal	1	.6763	.3405	.2153	.0919
	2	1.352	.681	.430	.183
	3	2.028	1.021	.645	.275
	4	2.705	1.362	.861	.367
	5	3.381	1.702	1.076	.459
	10	6.763	3.405	2.153	.919
	2,000	1,352.60	681.00	430.60	183.80
Cotton-seed hulls	1	.3637	.00244	.3232	.0232
	2	.727	.0048	.646	.046
	3	1.091	.0073	.969	.069
	4	1.454	.0097	1.292	.092
	5	1.818	.0122	1.616	.116
	10	3.637	.0244	3.232	.232
	2,000	727.40	48.80	646.40	46.40
Wheat bran	1	.5192	.1197	.3684	.0282
	2	1.038	.239	.736	.056
	3	1.557	.359	1.105	.084
	4	2.076	.478	1.473	.112
	5	2.596	.598	1.842	.141
	10	5.192	1.197	3.684	.282
	2,000	1,038.40	239.40	736.80	56.40

TABLE III. Showing Amount of Digestible Dry Matter and Nutrients in 1, 2, 3, 4, 5, 10, and 2,000 Pounds of Feeding Stuffs.—*Continued.*

Foods.	Weight. Lbs.	Dry matter. Lbs.	Total protein. Lbs.	Carbohydrates. Lbs.	Fats. Lbs.
Corn meal (cows)	1	.7139	.0532	.5916	.0361
	2	1.427	.106	1.183	.072
	3	2.141	.159	1.774	.108
	4	2.855	.212	2.366	.144
	5	3.569	.266	2.958	.180
	10	7.139	.532	5.916	.361
	2,000	1,427.80	106.40	1,183.20	72.20
Corn meal (pigs)	1	.7553	.0785	.6456	.0321
	2	1.510	.157	1.291	.064
	3	2.265	.235	1.936	.096
	4	3.021	.314	2.582	.128
	5	3.776	.392	3.228	.160
	10	7.553	.785	6.456	.321
	2,000	1,510.60	157.00	1,291.20	64.20
Corn meal (goats)	1	.7139	.0532	.5916	.0361
	2	1.427	.106	1.183	.072
	3	2.141	.159	1.774	.108
	4	2.855	.212	2.366	.144
	5	3.569	.266	2.958	.180
	10	7.139	.532	5.916	.361
	2,000	1,427.80	106.40	1,183.20	72.20
Cowpeas (swine)	1	.7748	.1828	.5664	.00708
	2	1.549	.365	1.132	.014
	3	2.324	.548	1.699	.021
	4	3.099	.731	2.266	.028
	5	3.874	.914	2.832	.035
	10	7.748	1.828	5.664	.070
	2,000	1,549.6	365.6	1,132.8	14.16
Potatoes (swine)	1	.1962	.0155	.1733	.....
	2	.392	.031	.346	.....
	3	.588	.046	.519	.....
	4	.785	.062	.693	.....
	5	.981	.077	.866	.....
	10	1.962	.155	1.733	.....
	2,000	392.48	31.04	346.6	.....
Rice bran, or douse (swine)	1	.8607	.0638	.7888	.0013
	2	1.721	.127	1.577	.0026
	3	2.582	.191	2.366	.003
	4	3.443	.255	3 155	.005
	5	4.303	.319	3.944	.006
	10	8.607	.638	7.888	.0130
	2,000	1,721.4	127.68	1,577.6	2.60
Rye bran (swine)	1	.592	.0972	.4747	.0161
	2	1.184	.194	.949	.032
	3	1.776	.291	1.494	.048
	4	2.368	.389	1.898	.064
	5	2.960	.486	2.373	.080
	10	5.92	.972	4.747	.161
	2,000	1,184	194.0	949.48	32.34
Carrots (horse)	1	.0995*	.0113	.0709	.....
	2	.199	.022	.141	.....
	3	.298	.034	.212	.....
	4	.398	.045	.283	.....
	5	.497	.056	.354	.....
	10	0.995	.113	.709	.....
	2,000	199.04	22.64	141.84	.....

TABLE III. SHOWING AMOUNT OF DIGESTIBLE DRY MATTER AND NUTRIENTS IN 1, 2, 3, 4, 5, 10, AND 2,000 POUNDS OF FEEDING STUFFS.—*Continued.*

FOODS.	Weight. Lbs.	Dry matter. Lbs.	Total protein. Lbs.	Carbo-hydrates. Lbs.	Fats. Lbs.
Corn and cob meal (goats)	1	.6727	.0545	.5904	.0297
	2	1.345	.109	1.180	.059
	3	2.018	.163	1.771	.089
	4	2.690	.218	2.361	.118
	5	3.363	.272	2.952	.148
	10	6.727	.545	5.904	.297
	2,000	1,345.40	109.00	1,180.00	59.40
Corn and cob meal (pigs)	1	.6462	.0633	.5638	.0288
	2	1.292	.126	1.127	.057
	3	1.938	.189	1.691	.086
	4	2.584	.253	2.255	.115
	5	3.231	.316	2.819	.144
	10	6.462	.633	5.638	.288
	2,000	1,292.40	126.60	1,127.60	57.60
Whole corn (pigs)	1	.7704	.0840	.6465	.0362
	2	1.540	.168	1.293	.072
	3	2.311	.252	1.939	.108
	4	3.081	.336	2.586	.144
	5	3.852	.420	3.232	.181
	10	7.704	.840	6.465	.362
	2,000	1,540.8	168.00	1,293.00	72 40
Corn (horse)	1	*.780	.0809	.6515	.0332
	2	1.560	.161	1.303	.066
	3	2.340	.242	1.954	.099
	4	3.120	.323	2.606	.132
	5	3.900	.404	3.257	.166
	10	7.800	.809	6.515	.332
	2,000	1,560.0	161.80	1,302.92	66.40
Oats	1	------	.0876	.4611	.0394
	2	------	.175	.922	.078
	3	------	.262	1.383	.118
	4	------	.350	1.844	.157
	5	------	.438	2.305	.197
	10	------	.876	4.61	.394
	2,000	------	175.20	922.20	78.80
Oats (horse)	1	.597	.0904	.4795	.0342
	2	1.194	.180	.959	.068
	3	1.791	.271	1.438	.102
	4	2.388	.361	1.918	.136
	5	2.985	.452	2.397	.171
	10	5.971	.904	4.795	0.342
	2,000	1,194.22	180.96	959.08	68.40
Cowpeas, ground (horse)	1	.7416	.178	.5479	.0019
	2	1.483	.356	1.095	.003
	3	2.224	.534	1.643	.005
	4	2.966	.712	2.191	.007
	5	3.708	.890	2.739	.009
	10	7.416	1.780	5.479	0.019
	2,000	1,483.20	356.0	1,095.80	3.80
Cowpeas, ground (ruminants)	1	.757	.1827	.5401	.0117
	2	1.514	.365	1.080	.023
	3	2.271	.548	1.620	.035
	4	3.028	.731	2.160	.046
	5	3.786	.913	2.700	.058
	10	7.572	1.827	5.401	.117
	2,000	1,514.4	365.40	1,080.18	23.48

* Organic Substance.

TABLE III. SHOWING AMOUNT OF DIGESTIBLE DRY MATTER AND NUTRIENTS IN 1, 2, 3, 4, 5, 10, AND 2,000 POUNDS OF FEEDING STUFFS.—*Concluded.*

FOODS.	Weight. Lbs.	Dry matter Lbs.	Total protein. Lbs.	Carbohydrates. Lbs.	Fats. Lbs.	Nutritive substance. Lbs.
Full cow's milk (calves)	1	.1474	.0309	.0536	.0534	.1441
	2	.294	.061	.107	.106	.288
	3	.442	.092	.160	.160	.432
	4	.589	.123	.214	.213	.576
	5	.737	.154	.268	.267	.720
	10	1.474	.309	.536	.534	1.442
	2,000	294.8	61.8	107.2	106.84	275.84
Buttermilk	1	.0851	.0305	.0442	.0025	.0805
	2	.170	.061	.088	.005	.161
	3	.255	.091	.132	.007	.241
	4	.340	.122	.176	.010	.322
	5	.425	.152	.221	.012	.402
	10	.851	.305	.442	.025	.805
	2,000	170.2	61.00	88.46	5.13	161.

II. FEEDING STANDARDS.

The composition and digestibility of feeding stuffs have been considered, and in the previous table the amounts of digestible nutrients in different quantities of foods were presented. The next question asked by the interested feeder is, How much and in what proportion should the digestible nutrients be fed to different animals for different purposes? This is a very difficult question to answer with accuracy. The results of a great many years patient investigation on this subject in Germany have found expression in the German Feeding Standards. In these, it has been attempted to give the needs of various animals, both as to amount of food and amount and proportion of digestible nutrients. The standards compiled by Wolff (tables IV and V) on this subject have been widely published and used in this country, and have, especially of late years, been the subject of discussion and criticism. We have no feeding standards of our own in America, and while the German ones no doubt need to be modified and changed to suit our climate, foods, and animals, yet the principle and example are good, and can serve as guides till we have accumulated sufficient data to formulate ones better suited to our particular needs.

It is to be remembered that the feeding standards presented do not represent invariable scientific facts, but are the average results of a great many carefully conducted experiments; then, too, the compositions and coefficients of digestibility of the feeding stuffs are the averages of analyses and digestion experiments. These facts borne in mind, the feeder will not expect certain definite results from them.

Another observation of interest in connection with feeding standards, is the greater proportion of protein to carbohydrates and fats

TABLE IV. FEEDING STANDARDS.—ACCORDING TO WOLFF.
Per day and per 1,000 *lbs. live weight.*

	Total organic substance.*	Nutritive (Digestible) Substances.			Total nutritive substance.**	Nutritive ratio.††
		Protein.	Carbohydrates.†	Fats.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1. Oxen at rest in stall	17.5	0.7	8.0	0.15	8.85	1 : 12.0
2. Wool sheep, coarser breeds	20.0	1.2	10.3	0.20	11.70	1 : 9.0
Wool sheep, finer breeds	22.5	1.5	11.4	0.25	13.15	1 : 8.0
3. Oxen moderately worked	24.0	1.6	11.3	0.30	13.20	1 : 7.5
Oxen heavily worked	26.0	2.4	13.2	0.50	16.10	1 : 6.0
4. Horses lightly worked	20 0	1.5	9.5	0.40	11.40	1 : 7.0
Horses moderately worked	21.0	1.7	10.4	0.60	12.70	1 : 7.0
Horses heavily worked	23.0	2.3	12.5	0.80	15.60	1 : 6.0
5. Milk cows	24.0	2.5	12.5	0.40	15.40	1 : 5.4
6. Fattening oxen, 1st period	27.0	2.5	15.0	0.50	18.00	1 : 6.5
Fattening oxen, 2d period	26.0	3.0	14.8	0.70	18.50	1 : 5.5
Fattening oxen, 3d period	25.0	2.7	14.8	0.60	18.10	1 : 6.0
7. Fattening sheep, 1st period	26.0	3.0	15.2	0.50	18.70	1 : 5.5
Fattening sheep, 2d period	25.0	3.5	14.4	0.60	18.50	1 : 4.5
8. Fattening swine, 1st period	36.0	5.0	27.5		32.50	1 : 5.5
Fattening swine, 2d period	31.0	4.0	24.0		28.00	1 : 6.0
Fattening swine, 3d period	23.5	2.7	17.5		20.20	1 : 6.5
9. Growing cattle:						
Age. Mos. — *Av. live weight per head.*						
2— 3 — 150 lbs	22.0	4.0	13.8	2.0	19.8	1 : 4.7
3— 6 — 300 lbs	23.4	3.2	13.5	1.0	17.7	1 : 5.0
6—12 — 500 lbs	24.0	2.5	13.5	0.6	16.6	1 : 6.0
12—18 — 700 lbs	24.0	2.0	13.0	0.4	15.4	1 : 7.0
18—24 — 850 lbs	24.0	1.6	12.0	0.3	13.9	1 : 8.0
10. Growing sheep:						
5— 6 — 56 lbs	28.0	3.2	15.6	0.8	19.6	1 : 5.5
6— 8 — 67 lbs	25.0	2.7	13.3	0.6	16.6	1 : 5.5
8—11 — 75 lbs	23.0	2.1	11.4	0.5	14.0	1 : 6.0
11—15 — 82 lbs	22.5	1.7	10.9	0.4	13.0	1 : 7.0
15—20 — 85 lbs	22.0	1.4	10.4	0.3	12.1	1 : 8.0
11. Growing fat pigs:						
2— 3 — 50 lbs	42.0	7.5	30.0		37.5	1 : 4.0
3— 5 — 100 lbs	34.0	5.0	25.0		30.0	1 : 5.0
5— 6 — 125 lbs	31.5	4.3	23.7		28.0	1 : 5.5
6— 8 — 170 lbs	27.0	3.4	20.4		23.8	1 : 6.0
8—12 — 250 lbs	21.0	2.5	16.2		18.7	1 : 6.5

NOTE.—The feeding periods mentioned in the above table have reference to the divisions of the whole time an animal is fed, and their respective lengths will depend on how long the animal is to be fed, its condition at beginning, and the judgment of the feeder.

*Represents the water-free food (or dry matter), less the ash.

†Nitrogen-free extract and crude fiber are taken together to form carbohydrates.

**Sum of the three preceding columns.

††See next page for explanation.

in the rations for young and growing animals, than in those for grown, fattening, and working ones. This is precisely as would be

TABLE V. Feeding Standards.

Per day and per head.

		Total organic substance.	Nutritive (Digestible) Substances.			Total nutritive substance.	Nutritive ratio.
			Protein.	Carbohydrates.	Fats.		
Growing cattle:	*Av. live weight*	Lbs	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Age. Mos.	*per head.*						
2— 3	150 lbs	3.3	0.6	2.1	0.30	3.00	1 : 4.7
3— 6	300 lbs	7.0	1.0	4.1	0.30	5.40	1 : 5.0
6—12	500 lbs	12.0	1.3	6.8	0.30	8.40	1 : 6.0
12—18	700 lbs	16.8	1.4	9.1	0.28	10.78	1 : 7.0
18—24	850 lbs	20.4	1.4	10.3	0.26	11.96	1 : 8.0
Growing sheep:							
5— 6	56 lbs	1.6	0.18	0.87	0.045	1.095	1 : 5.5
6— 8	67 lbs	1.7	0.17	0.85	0.040	1.060	1 : 5.5
8—11	75 lbs	1.7	0.16	0.85	0.037	1.047	1 : 6.0
11—15	82 lbs	1.8	0.14	0.89	0.032	1.062	1 : 7.0
15—20	85 lbs	1.9	0.12	0.88	0.025	1.026	1 : 8.0
Growing fat swine:							
2— 3	50 lbs	2.1	0.38	1.50		1.88	1 : 4.0
3— 5	100 lbs	3.4	0.50	2.50		3.00	1 : 5.0
5— 6	125 lbs	3.9	0.54	2.96		3.50	1 : 5.5
6— 8	170 lbs	4.6	0.58	3.47		4.05	1 : 6.0
8—12	250 lbs	5.2	0.62	4.05		4.67	1 : 6.5

Note.—The German pound equals 1.1 pounds avoirdupois. The above figures should therefore be increased correspondingly to represent American pounds, but in practice this is probably not necessary, since these weights represent only the approximate needs of the animals.

expected, since the bodily frame-work of the young animal is being built up at this stage of growth, and hence requires a larger proportion of protein, or flesh formers.

Nutritive Ratio.

"Total organic matter" in the above tables represents the water-free food, minus the ash; the "total nutritive substance" is the sum of digestible protein, carbohydrates, and fats; and the "nutritive ratio" is the ratio of the digestible protein to the sum of the digestible carbohydrates and fats, the fats being previously multiplied by 2.5 *

It will be seen from table IV that the standards are for animals of 1,000 pounds live weight. The standards are to be increased or diminished in proportion as the weight of the animal is greater or less than 1,000. In table V, they have been thus calculated to correspond with the weights of some animals weighing less than 1,000 pounds.

*Experimenters and feeders now generally use factors varying from 2.2 to 2.27 for bringing fats to the same nutritive basis as carbohydrates, and we agree with them that these factors are more nearly correct than 2.5; but we adhere to the latter in order that our ratios may be comparable with those in the German standard.

III. HOW STOCK RATIONS CAN BE CALCULATED.

A ration is the amount of food eaten by an animal per day. Table III contains data in a most available and handy form for compounding rations to correspond with the German standards just given, or with any other formula which may have proven valuable in the experience of the individual feeder; or for estimating the amounts of digestible nutrients the farm animals may now be consuming.

An example or two will make sufficiently clear the calculation and compounding of rations, so that the feeder, by applying results in table IV to whatever foods he may have, can make up rations to correspond with whatever formula he may wish. Suppose we want to compound a ration for a 1,000-pound milch cow, and have corn silage, cowpea-vine hay, corn meal, and cotton-seed meal from which to make it up. By reference to table III, we find the following amounts of nutrients corresponding to the weights of food taken.

Foods Taken.	Weight. Lbs.	Digestible. Protein. Lbs.	Digestible. Carbohydrates. Lbs.	Digestible. Fats. Lbs.
Corn silage	30	.216	3.984	.120
Cowpea-vine hay	12	1.117	4.605	.148
Corn meal	5	.266	2.958	.180
Total	47	1.599	11.547	.448

Using the amounts of corn silage, cowpea-vine hay, and corn meal for making the ration, it falls only slightly below the standard in amounts of carbohydrates and fats, but is notably deficient in protein, so we need to add to it a small quantity of some food rich in protein. Cotton-seed meal is a common food with us, and a good one for this purpose. We will then add to the ration as above, $2\frac{1}{2}$ pounds of cotton-seed meal:

Foods Taken.	Weight. Lbs.	Digestible. Protein. Lbs.	Digestible. Carbohydrates. Lbs.	Digestible. Fats. Lbs.
Ration as above	47	1.599	11.547	.448
Cotton-seed meal	$2\frac{1}{2}$	.840	.575	.240
Total	$49\frac{1}{2}$	2.439	12.122	.688
Standard for 1,000-pound cow	---	2.50	12.50	.40

Nutritive ratio of above ration, 1 to 5.67, obtained thus: (fats .688×2.5) + carbohydrates, (12.122) = 13.842 13.842÷protein, (2.439) = 5.67.

The 2½ pounds cotton-seed meal are thus seen to bring the ration very near the German standard for a 1,000-pound milch cow. There is a deficiency of carbohydrates, but the excess of fats compensates for this. It is near enough the standard for all practical purposes. The proportion of the foods in the above ration is not absolute and unchangeable, but may be varied in a number of ways, so as to get practically the same amounts and proportions of digesitible nutrients. What we would have understood is that the above is not the only ration that can be made from those foods containing those quantities of digestible nutrients, but a number may be by varying the proportions of them. This the feeder will have to do for himself, taking into account the quantity and foods he may have and the purposes for which he is feeding. The above is merely an example. If the animal weighs 700 or 800 pounds take seven-tenths ($\frac{7}{10}$) or eight-tenths ($\frac{8}{10}$) of the ration for the 1,000-pound animal, or whatever proportion the weight bears to 1,000.

It will be observed that the total "organic matter" was calculated in the feeding standards, but not in the ration presented above. Organic matter is merely a measure of the bulk of the ration, and, if the ration is not made too bulky, or too concentrated, it need not be further considered.

IV. SOME RATIONS FED IN NORTH CAROLINA, AND SOME RATIONS SUGGESTED.

On December 16, 1893, the Station sent to various feeders in the State inquiries relating to the care of stock. The following is extracted from this circular of information:

INQUIRIES AS TO CARE OF STOCK, AND FOOD AND RATIONS GIVEN.

DEAR SIR:—The N. C. Agricultural Experiment Station is carrying on some investigations with cattle foods, feeding, and care of stock, and it would be of service to us to get some information from breeders and feeders of stock in different parts of the State on these subjects. You will therefore confer a favor by a prompt reply to this circular, and by giving as definite information as possible on as many points as you can.

1. (*a*) What breed of cattle have you? (*b*) Purpose for which kept. (*c*) Sheep. (*d*) Swine. (*e*) Horses.

2. Give average number of each breed kept.

3. What part of the year does stock support itself by grazing?

4. What foods are used the remainder of the year, and how much of each?

5. What coarse food or grain is purchased, and what price for each article? Average prices are desired.

6. (*a*) Have you fed silage? (*b*) If so, to what stock, (*c*) and what crops were ensilaged? (*d*) Do you continue to use silage, and what crop do you favor as best for silage? Feeding stock—give your common or favorite ration with silage, or if you do not use silage, your most common ration of other foods for each kind of stock.

7. (*a*) What feeds do you give horses, and how much is allowed per day in pounds? State price or value per ton. (*b*) What feeds do you give mules? (*c*) What feeds do you give colts? (*d*) What feeds do you give cows? (*e*) What feeds do you give beeves? (*f*) What feeds do you give heifers? (*g*) What feeds do you give bulls? (*h*) What feeds do you give sheep? (*i*) What feeds do you give swine?

This circular was distributed to secure information in regard to feeding farm stock as practiced throughout the State. It was the desire of the Station, in turn, to distribute the information collected in this way, and thus give some knowledge of the best practices to those who have had least experience, and who will be best able to profit by the counsel of those who have made specialties in the several lines of feeding.

A considerable number of replies have been received from all sections of the State, and the practices and kind of feeds reported probably cover the range of foods and rations in common use. Some of these are given in the following pages.

It may not be out of place to remark here, that in the digestion work which has been done by the Experiment Station, there has been a greater proportion of digestible food obtained from coarse home-grown fodders, rich in carbohydrates, as fodder, shucks, straw, hay, corn silage, and cotton-seed hulls, when they have been fed with easily digestible by-products which are rich in the opposite class of protein compounds. Of this class of foods there are none to equal cotton-seed meal. It is safe in moderate quantities for nearly all domestic animals. The pig is the only animal we know of that is sure to be injured by cotton-seed meal.

Whenever a food like stover, shucks, straw, or coarse hay is to be fed, it is economical in effectiveness of the ration on the stock, to combine with it something else which carries with it a comparatively large proportion of protein. This may be obtained from clover, pea-vine, peanut, soy bean, or vetch hay, or silage made from these plants, or from by-products of the common grain foods.

It will thus become apparent to the stock-raiser that it will be to his advantage to raise the class of food needed to balance the coarse fodders produced on the farm, rather than purchase them. But many farms are not in condition to grow these at once. To help bring up the land to a productive state it is good practice to buy such cattle foods as cotton-seed meal, wheat bran, rice products, the grains when cheap enough, feed them to thrifty stock, and bestow careful attention on the manure piles and their application to the soil.

We would urge each feeder to learn to combine the foods he has, in order to produce rations as near as possible to the standards given in this bulletin. Then he should feed the ration in the proportions calculated, and as much to each animal as can be eaten up clean and regularly, without cloying the appetite of the animal.

It is never well to be dosing with condiments or stimulants, and yet it is both humane and economical to keep at hand a small stock of simple remedies for animals, to be administered when needed, but in no case unless the disease is known as well as the right remedy which ought to be employed. If any serious trouble ensues, a veterinarian should be consulted, but such simple things as salt and ashes, or copperas for worms, salts for derangements of digestion,

mucilage or sweet spirits of nitre, or of charcoal supplied to pigs, should be employed whenever their need is apparent. Common salt should be supplied freely to all animals. It is better to supply it in large solid lumps where the stock can lick off what they want at pleasure, than to depend on "salting" once or twice a week, or oftener. This salt will stand the weather well enough to be put out in pastures. A few animals may be found that will eat too much salt if thus provided, but they will be fewer than those that will get too much from periodic salting, if enough is allowed so all will get a taste in the pasture, as the greedy ones will secure the lion's share and suffer accordingly.

As might have been expected there are great differences in the time stock is self-supporting on the range. Not only is this difference graded somewhat for different classes of stock in a given locality, but by different management and care bestowed. In the East some stock is able to subsist with little or no attention, while some are fed for one, two, or three months, or are given a little food to supplement what can be gleaned during the shortest grazing month or two. The grazing season shortens toward the West until it is seven, six, or five months in the mountains, and feeders find it advantageous to feed the rest of the year. For dairy stock, even when ordinary animals may find support five to eight months, some foods are added to the dietary with advantage for nearly the whole of the grazing season. This shows that there is a growing recognition of the fact that the profits do not accompany self-support or feeding for maintenance, but follow in close connection the excess of food digested above what is required for support. It is also noticeable that dairymen, dealing with the maternal instincts and secretions where the most sensitiveness to adverse changes exist, find this out and profit by it before other feeders have awakened to the importance of considering the cost of food and feeding as secondary to the effect produced. This is doubtless true to some extent in housing stock. To provide comfortable quarters during cold or stormy weather, and shade or darkened sheds for protection against sun and troublesome insect pests not only marks an advance, but also points out the man who is looking for the little drains and leaks which absorb the profits of stock breeding.

Some Rations Which Are Being Fed in North Carolina.

RATIONS FED TO HORSES.

Few feeders give any definite quantities to their animals, or measure the food by the size or necessities of individuals, as might with propriety be suggested. Yet they often get the quantities with a pitchfork or pail much nearer the horse's needs than they know themselves. Oats are considered one of the best, if not the best, food for horses. Wheat bran is also a favorite food.

Adaptability to the purpose for which the animal is intended has

an important part in the selection of the dietary for horses. The young must be fed for growth, a good development of the muscles, and for strength and density of bone. Grazing on good grasses and clovers may be ideal foods for this purpose, but for part of the year colts must be fed for proper development. Some oats and bran and other foods are generally supplied, and it is quite natural to supply a certain ration of these most valuable and expensive foods, and then enough of the coarse, rough food for each one to get all that is needed for its complete sustenance, and to spare for the strengthening of the system by exercise.

Horses are not divided into classes here, but are treated generally, and rations may be included below for work on farm, draft, or road, and speed. This paper must be too brief to discuss these distinctions. Following are some rations which have been reported to the Station:

Rations fed to Horses.

1. Hay and cut corn stalks, cured from sowed corn. No silage.
2. A diversity of fodder, silage, corn, dry fodder, straw, cut sheaf oats. (This feeder doubtless gives wheat bran, and probably some threshed oats.)
3. Mixed feed; 3 pounds meal on oats and fodder mornings, with corn at noon and night, amounting to 10 pounds grain per day and head.
4. { Corn, 8 lbs, $15 per ton. / Hay 20 lbs, 8 per ton. } or { Fodder, 12 lbs, $20 per ton. / Oats, 15 lbs, 30 per ton. }
5. Corn, 10 pounds, at 60 cents per bushel; chop at $25 per ton.
6. Fodder and hay, corn and rye chop, all they will eat up clean.
7. Corn, 12 pounds; fodder, 5 pounds; hay, 5 pounds. Corn, at $17.85 per ton. Fodder and hay, $25.
8. Fodder, 15 pounds; corn, 10 pounds. Mules: fodder, 10 pounds; corn, 7 pounds.
9. 24 ears corn per day (about 150 to bushel), and all the forage they will eat at night.
10. Fodder, 4 pounds; straw, 6 pounds, corn; 12 pounds.
11. All the hay they will eat, and 8 ears of corn.
12. Corn fodder, oats, shucks, etc.
13. Corn fodder, ensilage, crushed corn, with cobs, and some turnips. Feed about what they will eat up clean.
14. Corn, oats, fodder, and hay. As much as they will eat without waste.
15. Cut shucks, or oats, and 1½ to 2 gallons corn meal per day. Mules same.
16. Corn and marsh hay.

Rations fed to Colts.

3. Same as for horses, only less. (See No. 3 above.)
4. Same as horses, meal, bran, oats, and fodder.
4½. Grass in summer, and corn, oats, and fodder in winter.
6. Wheat bran and corn meal mixed, and timothy hay.
9. 1 gallon oats, ½ gallon bran, and all the forage they will eat.

There have been so few digestion experiments made with horses, and these all foreign work and mostly on foods not included in the rations given above, that it is not easy to give calculated rations without assuming a great deal as to probable digestibility. There are a few, however, which may be compared with the recognized standard for horses, and in a general way some rational combinations can be suggested. It will be remembered by most horse owners and feeders that the stomach of the horse differs from that of the cow, sheep, or goat in capacity, and hence he must be fed somewhat more concentrated food than they to thrive as well. The horse should be well nourished for work, but should not be put at work with a great bulk of food in his stomach. Hence rations made up wholly or in large part of coarse or poorly digestible foods are badly suited to the needs of the animal and must fail to support the weight, or to keep him growing, or bearing daily burdens with cheerfulness, whether at the plow, wagon, sulky, or under saddle.

The rations must be adequate to the demand made on the animals. For this purpose they must contain a given amount of digestible compounds which have been found to be essential to animal nutrition, and these should be present in definite proportions as has been shown. These are according to Wolff's standard for 1,000-pounds live weight:

	Total organic substance. Lbs.	Nutritive (Digestible) Substance.				
		Albuminoids. Lbs.	Carbohydrates. Lbs.	Fats. Lbs.	Total nutritive substance. Lbs.	Ratio 1:—
Horses moderately worked	22.5	1.8	11.2	0.60	13.60	7.
Horses heavily worked	25.5	2.8	13.4	0.80	17.00	5.5

Unless rations Nos. 1 and 2 are fed with some grain or nitrogenous food, as clover hay, the animals would not be able to bear any continuous exertion without loss of flesh. Number 3 is a better ration for work and compares with the above standards as follows. We must suppose some certain amounts are fed; as 6 pounds corn, 4 of oats, and that with this the equivalent of 15 pounds of average hay has been consumed. This allows the digestible matter of the ration to have been

	Organic matter. Lbs.	Protein. Lbs.	Carbohydrates. Lbs.	Fats. Lbs.	Total nutritive substance. Lbs.	Ratio 1:—
15 pounds meadow hay (average)	11.979	0.539	5.340	0.056	5.935	
6 pounds corn	5.276	0.486	3.909	0.199	4.594	
4 pounds oats	3.444	0.362	1.918	0.137	2.417	
	20.699	1.387	11.167	0.392	12.946	8.75

This shows a deficiency of protein and fat. It is also low in organic matter, and the ratio is rather wide for light work. It will answer very well, however, for horses or mules of 850 to 950 pounds weight; and will doubtless prove a sustaining ration for such stock at ordinary work. Substituting for the oats 5 pounds of cowpeas, which cost about the same, and adding 5 pounds of hay, gives a better ration for work, and one which will sustain a heavier horse, or the same horse at harder work than he could do on the third ration above. This would contain:—

	Organic matter.	Digestible Matter in Pounds.				Ratio 1:—
		Protein.	Carbohydrates.	Fat.	Nutritive substance.	
Hay, 20 pounds	15.992	0.719	7.120	0.0747	7.913	
Corn, 6 pounds	5.276	0.486	3.909	0.199	4.594	
Cowpeas, 5 pounds	4.099	0.891	2.739	0.010	3.734	
	25.367	2.096	13.768	0.2837	16.241	6.9

Most of the hay should be fed at night, and least at noon, if any at all. This ration contains enough organic matter and an excess of carbohydrates, with a deficiency in protein and fat. It will doubtless sustain a 1,000 pound horse on medium to heavy work. This would need an occasional feed of roots, or green fodder.

The following would be a better ration than either of the above for light work, and it could be fed month in and out for a year, if desired:

	Organic matter.	Digestible Matter in Pounds.				Ratio 1:—
		Protein.	Carbohydrates.	Fat.	Nutritive substance.	
16 pounds hay, 4 pounds corn, 4 pounds peas, *1½ pounds ground flax seed	1.79	1.078	.729	13.75	13.45	7.

*From Stewart's Feeding Animals, p. 157.

For colts, the last named ration may be regarded as a good one, yet it would be improved by substituting 3 pounds of wheat bran for 3 of the corn, and feed only such portion of the whole ration as the colt's weight bears to 1,000 pounds, or, possibly, a little more than strict proportion would allow. Number 9 is a very good colt ration, if the "forage" is of good material and well cured.

Some Rations Fed to Milch Cows.

1. Cotton seed and bran, 3 to 6 pounds per day.
2. Ground and cooked peas, wheat foods, silage from 2 silos, 10 x 10 x 14. Cotton-seed hulls, corn meal. The foods are changed often.
3. Mixed feed twice per day, with corn and cob meal once.
4. Cotton seed, meal and bran, corn shucks and hay.
5. Straw, at $4, shucks, nubbins, chop.
6 Corn chop, and hay, or fodder.
7. Meal, 7 pounds; fodder, 5 pounds; hay, 5 pounds; cotton seed, 5 pounds.
8. Shucks and pea-vine hay, 7 pounds, at $10, and 3 pounds wheat bran and shorts, at $20.
9. Cotton seed, 7 pounds, with one gallon of the following mixture: Corn, 2 bushels, oats, 1 bushel, wheat bran, 1 bushel.
10. Cotton seed, 6 pounds; pea meal, 10 pounds. Do not stall feed. Dry cows all the straw and shucks they will eat.
11. Fodder mornings and hay evenings.
12. Shucks, straw, turnips, pumpkins, potatoes, short corn, bran, etc
13. All stock supports itself the year through. (From Carteret County.)
14. Corn fodder, ensilage, crushed corn with cobs, some turnips.
15. Shucks, straw, chaff, clover and pea hay, with some corn meal, wheat bran, and cotton seed.
16. Cut shucks, and 1½ gallons corn meal to cows.
17. Hay, beets, turnips, and bran. Cotton seed and hay and corn. Wheat bran and cotton seed and shucks.

Most of these rations are not definite enough to make a calculation on, but a few of them have been so stated that they can be used. If feeders will only weigh and measure and observe proportions a little more closely, they can save themselves money by lessening the cost of feeding, and in increasing the value of the products.

Ration No. 2 presents some good and cheap foods, but no amounts are given. In the following calculation all the amounts are assumed:

	Protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio.
5 pounds wheat bran	.598	1.842	0.141	2.581	
40 pounds silage	.288	5.312	0.16	5.76	
5 pounds cowpeas* (ground)	.914	2.700	0.059	3.637	
	1.800	9.854	0.36	12.014	5.9

*Digestion coefficients for field beans. Zusam. u. Verd. der Fut., 1891.

	Organ. Sub.	Nitrogenous.	Fat.	N-free ext.	Fiber.
With ruminants, p. 1214	88.88	88.05	81.51	91.69	71.89
Same from p. 1111	89.29	88.12	86.67	91.63	71.89
Our own average of the 14 determs. given on p. 1111 is	90.77	90.51	89.46	92.24	70.32

This ration was calculated using the ratios given on page 1216 of Zusammensetzung und Verdaulichkeit der Futtermittel, von Dr. Th. Dietrich und Dr. J. König. Afterwards looking over the experiments on which the average was based, we were struck by the discrepancy of the mean figures (pages 1111 and 1214). On averaging the 14 determinations given, the mean obtained was different from either of those given in the book. Some of the published figures must be in error therefore, but the first calculation is allowed to stand unchanged until a proper correction can be made.

This ration would be a very good one, and quite sufficient for an average cow of 800 pounds weight. It contains a slight excess of carbohydrates, and is a little deficient in protein, which makes the ratio rather wider than the standard. The average cow will probably leave some of the silage, and will thus reduce the portion consumed to a close approximation to the standard. For larger cows make it 50 pounds silage, 5 of bran, and 7 of peas. The composition will then stand about as follows:

	Protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio.
50 corn silage 5 wheat bran 7 cowpeas	2.24	12.26	.384	13.48	5.9

If this is increased by one-ninth of itself it will closely approximate the standard for 1,000 pounds live weight, but in practice we have found rations under the standard to meet the needs of our stock. The ration consumed will be farther than the above from the standard. A ration often fed at the Experiment Farm to cows of about 900-pounds weight consists of:

	Protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio. 1:—
45 corn silage	0.324	5.976	0.18		
3 cotton-seed meal	1.021	.645	0.275		
6 Wheat bran	0.718	2.310	0.169		
	2.063	8.931	0.624	11.618	5.1

This ration, measured by the recognized standard, appears to be deficient in quantity, but has been fed to a 1,000-pound cow, and proved sufficient when five to six months in calf and milking five to seven pounds ($\frac{3}{4}$ gallon) of milk per day. Another cow in full flow of milk, $3\frac{1}{2}$ gallons per day, was fed 80 pounds of green rye, and 5 pounds hay, with 9 pounds cotton-seed meal and bran mixed two to one. The following was eaten:

	Total dry mat.	Protein.	Carbohydrates.	Fat.	Nutri. sub.	Ratio 1:—
75 pounds rye	11.75	1.483	6.1725	.428	8.083	
3 pounds cotton-seed meal, 6 pounds wheat bran,	8.02	1.739	2.955	.444	5.138	
	19.77	3.222	9.027	.872	13.221	3.48

The ration given under No. 7 can be thus stated:

	Protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio.
Corn meal, 7 pounds	.372	4 141	.252		
Corn fodder, 5 pounds	.267	2.167	.098		
Hay, 5 pounds	.149	1.894	.052		
Cotton seed, 5 pounds	.491	1.396	.844		
	1.179	9.598	1.246	12.023	10.78

To improve this ration and make it correspond closely to the standard, except less carbohydrate and a large excess of fat, the corn meal should be dropped, and 4 pounds of cotton-seed meal added, with 5 pounds more of fodder. The ration would then stand as follows:

	Protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio 1:—
Pulled corn fodder, 10 pounds	.534	4.334	.196		
Hay, 5 pounds	.149	1.894	.052		
Cotton seed, 5 pounds	.491	1.396	.844		
Cotton-seed meal, 4 pounds	1.362	.861	.367		
	2.538	8.485	1.459	12.482	4.78

This would do very well for a cow of 1,000 to 1,100 pounds, and perhaps would support 1,200 pounds weight.

A Guilford County dairyman's ration is as follows:

	Cost. Cents.	Digestible protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio 1:—
Cotton-seed hulls, 20 pounds	4.25	.0488	6.464	.464		
Hay, 5 pounds	2.50	.1495	1.939	.052		
Oat straw, 5 pounds	0.625	.070*	2.228	.044		
Cotton-seed meal, 3 pounds	3.60	1.008	.691	.288		
Corn meal and bran, 7½ pounds (Taken as 5 and 2½.)	8.25	.266 .299	2.958 .911	.180 .0705		
	19.225	1.841	15.191	1.099	18.131	9.76

Suppose he changes to the following:

Hay, 10 pounds	5.00	.299	3.878	.104		
Oat straw,* 20 pounds	2.50	.280*	8.912	.176		
Cotton-seed meal, 5 pounds	6.00	1.681	1.152	.480		
Corn meal, 2.5 pounds	2.75	.133	1.479	.090		
Wheat bran, 2.5 pounds	2.75	.299	.811	.0705		
	19.00	2.692	16.332	.9205	16.945	6.92

This calculation is based on the tabulated analyses given in bulletin No. 90. Probably cows will leave some straw which will reduce the nutritive substance and ratio, and as his cows doubtless fall short of 1,000 pounds this ration should prove sufficient for them.

The additional rations given below will be found of interest in this connection:—

Rations with annual clover hay. *Ration No. 1:* One cow of nearly 700 pounds weight (697) was fed 18 pounds of hay daily for some time; she ate 14.64 pounds. See ration No. 1 below. *Ration No. 2* was fed to the same cow. Corn meal is a better combination with this hay. *Ration No. 3:* Crimson clover hay, oat straw, and a mixture of wheat bran 2, ground oats 2, and corn meal 1, was fed a growing bull. *Ration No. 4:* Feed allowed dry cows November, 1892, at the Experiment Farm.

*Stewart's Feeding Animals, p. 155.

This ration would be a very good one, and quite sufficient for an average cow of 800 pounds weight. It contains a slight excess of carbohydrates, and is a little deficient in protein, which makes the ratio rather wider than the standard. The average cow will probably leave some of the silage, and will thus reduce the portion consumed to a close approximation to the standard. For larger cows make it 50 pounds silage, 5 of bran, and 7 of peas. The composition will then stand about as follows:

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	Protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio. 1:—
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3 cotton-seed meal	1.021	.645	0.275		
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	2.063	8.931	0.624	11.618	5.1

This ration, measured by the recognized standard, appears to be deficient in quantity, but has been fed to a 1,000-pound cow, and proved sufficient when five to six months in calf and milking five to seven pounds ($\frac{3}{4}$ gallon) of milk per day. Another cow in full flow of milk, $3\frac{1}{2}$ gallons per day, was fed 80 pounds of green rye, and 5 pounds hay, with 9 pounds cotton-seed meal and bran mixed two to one. The following was eaten:

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	19.77	3.222	9.027	.872	13.221	3.48

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Corn meal, 7 pounds	.372	4 141	.252		
Corn fodder, 5 pounds	.267	2.167	.098		
Hay, 5 pounds	.149	1.894	.052		
Cotton seed, 5 pounds	.491	1.396	.844		
	1.179	9.598	1.246	12.023	10.78

To improve this ration and make it correspond closely to the standard, except less carbohydrate and a large excess of fat, the corn meal should be dropped, and 4 pounds of cotton-seed meal added, with 5 pounds more of fodder. The ration would then stand as follows:

	Protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio 1:—
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Hay, 5 pounds	.149	1.894	.052		
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Cotton-seed meal, 4 pounds	1.362	.861	.367		
	2.538	8.485	1.459	12.482	4.78

This would do very well for a cow of 1,000 to 1,100 pounds, and perhaps would support 1,200 pounds weight.

A Guilford County dairyman's ration is as follows:

	Cost. Cents.	Digestible protein.	Carbohydrates.	Fat.	Nutritive substance.	Ratio 1:—
Cotton-seed hulls, 20 pounds	4.25	.0488	6.464	.464		
Hay, 5 pounds	2.50	.1495	1.939	.052		
Oat straw, 5 pounds	0.625	.070*	2.228	.044		
Cotton-seed meal, 3 pounds	3.60	1.008	.691	.288		
Corn meal and bran, 7½ pounds (Taken as 5 and 2½.)	8.25	.266 .299	2.958 .911	.180 .0705		
	19.225	1.841	15.191	1.099	18.131	9.76

Suppose he changes to the following:

Hay, 10 pounds	5.00	.299	3.878	.104		
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Cotton-seed meal, 5 pounds	6.00	1.681	1.152	.480		
Corn meal, 2.5 pounds	2.75	.133	1.479	.090		
Wheat bran, 2.5 pounds	2.75	.299	.811	.0705		
	19.00	2.692	16.332	.9205	16.945	6.92

This calculation is based on the tabulated analyses given in bulletin No. 90. Probably cows will leave some straw which will reduce the nutritive substance and ratio, and as his cows doubtless fall short of 1,000 pounds this ration should prove sufficient for them.

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*Stewart's Feeding Animals, p. 155.

Name and Amount of Article Fed.	Total dry matter. Lbs.	Digestible Substance. Protein. Lbs	Carbohydrates. Lbs.	Fats. Lbs.	Nutritive substance. Lbs.	Ratio 1:—
Ration No. 1.						
Crimson clover hay alone. Fed 18 pounds; eaten, 14.64	13.05	1.625	5.792	.24	7.568	3.88
Am't of above per 1,000 live weight	18.72	2 331	8.181	.344	10.856	
Ration No. 2. Fed to same cow:—						
Fed 18 lbs. crimson clover hay; eaten, 14.24	12.693	1.580	5.546	.233		
Fed 4½ lbs. cotton-seed meal; eaten, 4.50	4.152	1.552	.924	.461		
	16.845	3.132	6.470	.694	10.296	2.66
Am't. per 1,000 lbs. live weight	23.139	4.302	8.887	.953	14.142	
Ration No. 3. Eaten by bull.						
10½ crimson clover hay	9.361	1.307	4 587	.131		
10½ oat straw	9.490	.1512	4.475	.069		
4 wheat bean	3.508	.572	1.706	.103		
4 ground oats	3.560	.338	1.844	.157		
2 corn meal	1.684	.124	1.235	.067		
31. Total consumed for 1,400 lbs weight	27.603	2.492	13.847	.528	16.867	6 25
Standard for age 18–24 mos. and 850 lbs. weight per 1,000 live weight	24.00	1.60	12.00	0.3	13 90	8.00
Standard raised for 1,400 lbs	33.6	2.24	16.80	0 42	19.46	

On a ration containing approximately two (2) ounces more of fat, and four (4) ounces of protein, with three (3) pounds less of carbohydrates than would be required in strict proportion for an animal of this weight according to the ratio, there was a gain of 2.2 pounds per day for the growing bull fed on ration No. 3.

Name and Amount of Article Fed.	Total dry matter. Lbs.	Digestible Substance. Protein. Lbs.	Carbohydrates. Lbs.	Fats. Lbs.	Nutritive substance. Lbs.	Ratio 1:—
Ration No. 4.						
20 lbs. cotton-seed hulls	17.08	.056	6.026	.592		
5 lbs. { cotton-seed meal 1 / wheat bran 2 }	4.46	.973	1.621	.265		
	21.54	1.029	7.647	.857	9.533	9.5

The rations suggested below are reprinted from bulletin No. 80, page 14, and give combinations with corn silage in various proportions.

"Rations for stock to include silage may be made in endless variety, according to the animals to be fed, the object of feeding, and the other foods available to be used with it. Silage from well-matured corn will keep stock in store or growing condition, and some may even fatten slowly on it; but for fattening, growth, work, or production of milk, best results require some other food more highly nitrogenous to be used with the silage. Of these cotton-seed meal is one of the best. In this State, where cotton-seed meal is a by-product and can be purchased without great cost for transportation, it should become one of the common staple articles of cattle food. Cotton-seed meal alone is one of the best additions to silage for a good ration for milk or beef. Below are given some rations which may be fed to milch or beef-cattle of 700 to 800 pounds weight and for about 1,000 pounds. The first figure under each number are for the smaller animal:"

	No. 1. Pounds.		No. 2. Pounds.		No. 3. Pounds.		No. 4. Pounds.		No. 5. Pounds.		No. 6. Pounds.		No. 7. Pounds.	
Corn silage	30	40	40	50	24	30	30	40			30	40		
Cotton-seed meal	4	5	3½	4½									2¼	3
Cotton-seed hulls	8	10			4	5							6	7½
Clover hay									13	17½			8	10
Hay, cowpea-vine							12¼	15						
Orchard-grass hay			4	5										
Lucerne, or alfalfa					8	10								
Corn meal									4½	6			6	7½
Wheat bran					5	6			3	4	4½	6	2	2¼
Field peas, ground											4½	6		
Total lbs. in rations	42	—55	47½	—59½	41	—51	42½	—55	20½	—27½	39	—52	24¼	—30½

Rations fed to Beeves.

4. Chop and nubbins.

7. Meal, 13 pounds; fodder, 5 pounds; cotton seed, 8 pounds.

9. Only keep 8 to 10 head to eat up shucks and refuse forage. Haul up cornstalks and cattle strip them. Turn on clover and feed stronger in March. Give cotton seed, bran, and nubbins, corn and meal, and sell when only in fair condition.

10. All the straw they will eat, and 2 or 3 quarts of cotton seed per day.

12. (Same as cows.)

14. (Same as horses, mules and cows.)

15. (Same as cows.)

16. Corn meal.

18. Pasture.

Rations fed to Young Stock and Bulls.

1. Only pea vines, oat straw, and cut cornstalks.

5. Straw, shucks, small quantity chop.

6. (Same as cows.)
7. Corn meal, 3 pounds, fodder or hay, 6, cotton seed, 3.
14. (Same as horses and mules.)
15. (Same as cows.)

The rations fed to beeves indicate thriftiness in utilizing the waste products of the farm. This was urged in a former bulletin (No. 81), where, in discussing the result of a feeding experiment, it was stated that, "*It pays to use up all rough cattle food which can be gathered, and at a season when it is at its best*, that is, perishable articles, as potatoes, roots, garden waste early in the season, in connection with cotton-seed hulls and meal." In order to succeed best with such feeding, it must be done rationally. Thus, if in No. 9, above, the cattle are fed cotton seed in limited amount when on clover, or while being fed on shucks, refuse, and cornstalks, then they should be fed some richly nitrogenous food or by-product of smallest possible cost to balance ration and get the most out of the coarse food. Compare bulletin 87D, p. 32, p. 47. See also parts C. and D. of bulletin 93 on this subject. It does not pay a feeder to sell off stock when only in fair condition. Stock should be prepared for market when it is likely to bring the best prices, and in the fattest condition the market will pay for. Nearly every ration for beef would be improved by addition of cotton-seed meal.

We might lay down as a general rule for the advantage of the stock fed for gain in total amount digested from the coarse foods for beef, and an advantage also in increasing the value of manure, is to *give every animal a daily ration of cotton-seed meal equal to one-half pound for every 100 pounds of live weight, and all the roughage it will eat*, and you cannot go very far astray in your ration, especially if the animals get a little green grass or clover in addition. Where plenty of clover, cowpea-vines, peanut vines, or soy-bean fodder can be had, corn meal may be used instead of cotton-seed meal. With the directions given previously in this bulletin any feeder can easily "balance" the ration out of such foods as he may have, or can easily procure.

For some additional rations for beeves, see discussion in this bulletin under cows, page 307; also refer to bulletins 81 and 93, and to those on digestion, 80C, 87D, and 97.

Rations fed to Sheep.

3. Clover hay, meal, fodder, etc.
4. Oats, cotton-seed meal, and fodder.
5. Small quantity of corn and top fodder.
6. Corn and fodder.
7. Grain, 1 lb.; hay, 1 lb.; fodder, 1 lb.
10. Cotton-seed with corn mostly, and fodder. Never has weighed.
11. Fodder and corn.
12. Cotton-seed mostly, peas, etc.
15. Rag-weed hay, shucks, chaff and cotton-seed with meal and bran.

17. Hay, turnips, and corn. (Feeding 100 to 200 Shropshires.)
17½. Corn and turnips.
18. Cotton-seed in severe weather.

This list of rations shows that few if any breeders are accustomed to feed sheep more than enough to assist bare pastures or to help the sheep over severe periods in winter or spring. More care and feeding ought to pay well, especially with ewes and early lambs and fattening mature sheep. It is a good practice to keep corn or meal, cowpeas or bran, or cotton-seed where the growing lambs can get to it every day at will, besides what they can get from the troughs when the dams are fed once every day with bran, corn, peas or beans, or in place of these, cotton-seed meal.

Feeding from 4 to 6 ounces of cotton-seed meal per day and head, with what coarse food the sheep can get from rather poor pasture, or from straw, poor hay, or stover, would keep a flock in good condition. One-half pint to one pint of beans or peas should have about the same effect. Quiet and gentle handling to keep the animals tame and free from excitement are valuable adjuncts to profitable sheep feeding.

For growing sheep per head and day, the standard varies from 5 to 6 months to 15 to 20 months as follows:

	Live weight.	Total organic substance	Protein.	Carbohydrates.	Fat.	Total nutritive substance	Ratio :1—
	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	
5 to 6 months	56.	1.60	0 18	0.87	.045	1.095	5.5
15 to 20 months	85.	1.90	0.12	0.88	.025	1.047	8.0

A fairly balanced ration for the first consists of one pound each of wheat bran and red-clover hay, while one pound of the same hay and one of corn meal is almost as near the standard for the older sheep.

	Protein.	Carbohydrates.	Fat.	Total nutritive substance.	Ratio 1 :—
1 Pound bran	.119	.368	.028		
1 Pound red clover hay	.061	.360	.010		
	.181	.728	.038	.948	4.5
1 Pound corn meal	.053	.591	.010		
1 Pound red clover hay	.061	.360	.036		
	.114	.951	.046	1.113	9.3

An average of these two rations is more nearly balanced for a 75-pound sheep than either of these is for the younger or older sheep. The first ration above can be improved by using 12 ounces of bran and 6 ounces of corn meal instead of the pound of bran, while in the latter 12 ounces of corn meal and 4 ounces of bran will reduce it very near to the standard.

Rations fed to Swine.

1. Ship stuff and buttermilk.
2. Corn and meal and bran.
3. Corn, clover in summer, potatoes, slop, etc.
4. Corn and grass. Six lbs. corn, at $15 ton, per day and head.
5. Corn and rye meal.
6. Corn.
7. Corn, 4 lbs., peas, 4 lbs.
8. Corn, 7 lbs. at $22.50 ton.
9. Suckling sows fed all they will eat of a mixture of corn, 3 bushels; oats, 1 bushel; wheat bran, 1 bushel. Fattening swine 16 to 30 ears corn per day then soured meal. A lot of 14 two months-old pigs are being fed 1 gallon cooked cowpeas, 1 gallon bran and 6 ears corn. They have the run of a clover and lucerne patch when the weather is suitable.
11. Corn.
12. Corn, peas, sweet and Irish potatoes, turnips, bran and slop.
14. Crushed corn and cobs, corn, potatoes and meal cooked. All the corn they will eat when fattening.
15. Mostly corn, with some bran and meal.
16. Corn and potatoes, but mostly slop.
17. Bran, milk, and clover.
18. Corn and sweet potatoes.
19. Corn, vegetables and fruit.

The pig consumes a wide range of foods and is capable of converting them into meat very rapidly. Many rations can be converted into growth so fast that it may often be impossible to convince a feeder that his combinations can be so improved that his pigs will make more profitable growth. The new ration may also be better balanced and it may be so chosen as to cost less pound for pound or for a pound of gain produced from it, than before.

It is customary to keep sour food for pigs, under the impression that the souring is a great aid to a pig's digestion. Slightly soured food may in some cases show equal or even greater gains than fresh or unsoured, but the sour swill-barrel is very apt to become filthy enough to be a standing menace, even if it does not cause indigestion and disease. Sound, freshly prepared food is the best for the pig. Whether the grain food should be fed dry, or moistened, is a question upon which there is quite an accumulation of data on both sides. A pig can undoubtedly be induced to eat more moistened food, and therefore gain more for a time than if fed dry food and water in separate vessels. Yet, sooner or later, the pig so fed can be surpassed by his dry fed brother in net result. For a short fattening period, therefore, it may be best to moisten the food and induce the pig to eat as much as possible and crowd his digestive powers for greatest net returns.

Many of the above rations are capable of, and are being put together rationally, to produce good results. Perhaps they are not

"balanced," but some of them could scarcely miss it at times. Ship stuff and buttermilk in ration 1, corn and bran in No. 2, and corn and clover in ration 3, may balance well, as also the latter ration if peas are fed with potatoes and slop. Corn and grass, corn and rye, rations 4 and 5, corn and peas in No. 7, and especially those of No. 9, are in the right direction. Numbers 12, 15, and 17 are good rations, and the only question about them is in regard to proportions of nitrogenous to carbonaceous foods which are used. In order to balance corn, potatoes, vegetables, and roots or fruit, there is hardly anything equal to peas boiled or ground, or even fed raw and whole, if pigs will eat them well.

Looking at ration No. 1 again, it is seen to be too wide in ratio and ill proportioned if fed in equal weights, as follows:

	Total dry matter.	Protein.	Carbohydrates.	Fat.	Nutritive substance.
2 lbs. corn meal	1.688	.168	1.293	.072	
2 lbs. rye bran	1.767	.194	.949	.032	
	3.455	.362	2.242	.104	2.709

There is dry matter sufficient for a 125-lb. pig and too little protein for a 50-lb. one, while carbohydrates and nutritive substance are in excess. If change is made to 2 pounds corn and 4 of rye bran the ration is still faulty, but now add 20 pounds of buttermilk and it becomes almost exacty the "standard" for three 50-lb. pigs.

2 lbs. corn	1.688	.168	1.293	.072		
4 lbs. rye bran	3.535	.388	1.898	.064		
	5.222	.557	3.192	.1372	3.886	6.3
20 lbs. buttermilk	1.702	.610	.884	.05		
	6.924	1.167	4.076	.187	5.43	3.9

Considering No. 7, in which definite amounts are stated, this ration is seen to be very well balanced for 100-pound pigs, and should be enough according to the standard for two pigs of that weight.

Corn, 4 lbs	3.376	.336	2.586	.144		
Peas, 4 lbs	3.099	.731	2.265	.028		
	6.475	1.067	4.852	.173	6.092	5.0

Thus every feeder may, by care in weighing foods and pigs occasionally, and by using the tables in this bulletin, adjust the rations fed to pigs of all sizes as well as to sheep, cows, work or fattening cattle and growing stock of all kind, so as to get the most effect from the food consumed.

V. COMMENTS OF PRACTICAL BREEDERS AND FEEDERS.

From Elias Carr, Jr., Old Sparta, Edgecombe County. Silage is made of corn and peavines. It is fed to cows, hogs, sheep, and mules. Hogs are fed on "anything and everything about the farm that otherwise would go to waste, and fatten principally on peanuts left in the ground after harvest."

T. B. Parker, Goldsboro, Wayne County, makes silage of "corn and cow-pea vines, with crab grass mixed in," and feeds it to cattle and horses.

W. L. Kennedy, Falling Creek, Lenoir County, whose colts are becoming so well known as to point him out as a successful breeder and feeder, says: I raise my own feed, and have never used ensilage. His ration for horses is: Corn, 5 lbs.; oats, 4 lbs.; bran, 2 lbs.; hay, 15 lbs. For mules, corn and fodder. But it is his ration for colts the horsemen wish to know. It is bran, 2; oats, 8; hay, 10 pounds. Mr. Kennedy's ration for cows might also be a model for very many dairymen. It is peavine hay, 30; corn meal, 8; and bran, 2 pounds.

Thomas A. Cox, Cullowhee, Jackson County, feeds grade Holstein-Friesian cows, 2 lbs. cotton-seed meal; 4 lbs. wheat bran; 6 lbs. corn and cob meal per cow of 900 pounds weight, with hay; oat straw, or corn stalks with fodder and shucks (stover). All the coarse food the cows will eat is allowed. Some of the time, wheat bran is replaced by a mixture of rye, oats, and cowpeas grown at home, as is all the feed except bran and cotton seed meal. Larger or smaller animals are fed more or less grain in proportion to weight. Other neat stock fed same ration in proportion to size. Pigs are grown on clover pasture, slops, skim-milk and corn, and fattened on mast, which some years is very abundant. Mr. Cox hopes to be prepared for silage this year.

Jas. M. Wright, Fairly's, Richmond County, feeds to cows: hay, corn, fodder and shucks, cotton seed, cotton-seed hulls, and meal and peavine hay. Never saw but one silo and have the very poorest opinion of such an arrangement to save feed for animals. If water is plentiful rather have dry feed. Our people do not invest in silos." [Doubtless on better acquaintance, Mr. Wright would have a higher opinion of the silo.]

J. R. Moore, Shelby, Cleveland County, feeds Angora goats in rough weather, some cotton seed, a little meal, and some fodder. He uses plenty of salt. For pigs and breeding sows, one part each bran, ground oats, and shorts. Places plenty of charcoal where they can get it. When pigs are fed *ad libitum* in this way they will gain one and a half to two pounds per day. Occasionally a mess of well charred corn is given them.

W. W. Boyce, Pineville, Mecklenburg County, after giving some details as to bundles of fodder, ears of corn, and gallons for the units, says: "We really have no system of feeding. I wish I could get out of the old haphazard ways." He has only to weigh a few ears or bundles of fodder several times to get near the average weight of them; then by adopting a given number of bundles or ears, or quarts to represent so much weight, apply the method of balancing a ration, and when he has arrived at a satisfactory point as regards the relation of one class of nutrients in proporton to the other, present the ration to the animals in as near those proportions as pos-

sible. This should help him harmonize the "old haphazard way" of keeping the horse, cow, sheep, or pig in good condition, with the more exact one of trying to do so at the least expense or waste of food.

R. O. Patterson, Governor's Island, Swain County, observes that his cattle "do much better housed in comfortable barns than others on more feed including a lot of grain, but without shelter." There is a great deal in this observation, and on many a farm, especially in western North Carolina, where the climate is colder, the saving in food, and the gain from better condition of stock, would well repay a moderate outlay for comfortable quarters during winter.

From Baron E. d'Alinge, manager of the agriculture department of the Biltmore estate, Biltmore, Buncombe County, some valuable notes on soiling and feeding the year round have been received. For horses, 10 to 12 pounds of hay cut up with straw is fed with 8 lbs. corn, ground; 2 qts. oats, ground, and 3 lbs. bran. Mules are fed 10 to 12 lbs. hay cut up with straw, and 8 to 10 lbs. ground corn, 3 lbs. bran, and 1 lb. cotton-seed meal. If many feeders would note this use of cotton-seed meal and replace some of the corn or hay fed to working horses, mules and steers, better results would be realized from the feeding.

It is of interest to give other facts in regard to the stock and feeding at the Biltmore estate. Of the 128 cows kept for dairy use and for sale, twelve are full blooded Jerseys, and the rest are high grades. There are 58 heifers, 20 heifer calves and 12 steer calves. Of sheep 200 grade Southdowns are kept, and 70 Berkshire swine. Of horses there are 16 grade Percheron, 91 mules and 32 riding and driving horses. The stock are not grazed at all. Corn, oats, bran, cotton-seed meal, hay, oats and wheat-straw are fed. The soiling crops are crimson clover, rye, oats, peas, millet, broadcast sorghum, fodder corn, millo-maize, teosinte, etc. These are given in the order named, beginning with the end of March and ending in November. Corn when not raised on the farm, costs 58 to 62 cents per bushel, and oats 45 cents per bushel, wheat bran $18 per ton, and cotton-seed meal $22 per ton. Silage is fed to steers and cows, and corn, teosinte, cowpeas, millet and crimson clover, are used as silage crops. Corn, peas, millet, teosinte and cowpea-vines, are put into the silo in alternate layers. The common and favorite ration with silage is 35 to 40 lbs. of silage with 3 lbs. corn meal, 3 lbs. bran and 1 lb. cotton-seed meal. Will never stop using the silo and ensilage.

A year's fare of the Biltmore cows may, then, be taken from the following rations and the above soiling crops: "Ensilage, at two feeds, 40 lbs.; cut corn fodder, 4 lbs., one feed; ground corn, 3 lbs.; bran, 4 lbs., and cotton-seed meal, 1 lb.; varying for individuals according to capacity of digestion and yield."

Soiling crops follow in succession as given above, accompanied with more or less grain adapted to supplement the crop to produce a ration adequate to the demand of each animal. Between soiling and ensilage, mangold-wurtzels and sugar beets are fed.

Dr. L. L. Staton, of Tarboro, makes silage of corn and cowpea-vines. He feeds to cows of this silage, 15 lbs. with 3 lbs. cotton-seed meal, and supplies in addition all the cotton-seed hulls they will eat.

J. W. McGregor, Lilesville, Anson County, says: "We have given very little attention to raising stock here, as ours has been a cotton-raising section. But since cotton has fallen in price below the cost of production, much interest is now being given to this branch of industry, especially to hogs and horses and mules, and a great improvement is noticeable in this particular. We can raise all the grain and stock we need if the attention we have hitherto given to cotton raising is accorded to stock."

H. S. Harrison, Medoc, Halifax County, says: "Corn, oats, clover hay, ensilage and roots are used as cattle foods. We buy none, but grow them all at home. We have been using silage for quite a while, growing corn and pea-vines for it principally, and have fed both horses and cows on it with good results."*

Capt. B. P. Williamson, Raleigh, Wake County, who is doing so much to arouse interest in the best strains of American horses, says: "I produce all my hay and oats, but buy wheat bran. Hay can be produced in North Carolina for $8 per ton and oats for *one cent* per pound. Bran $15 per ton. I believe we can breed and raise *fine horses*, as fine and of as good size and as cheaply as can be done in *any State*, if we will go at it intelligently." His ration for idle (?) horses is, 8 pounds oats or bran, and 6 pounds hay. For colts 4 pounds oats or bran, and 4 pounds hay. His hay is clover and orchard grass, red top, and crab grass.

Messrs. Holt & Homewood, Burlington, breed Devon, Ayrshire, and Dutch Belted cattle, Cotswold, Shropshire and Southdown sheep and Clydesdale horses, and *sell hay at $20 per ton.* No cattle food is purchased. Horses are fed cut feed and 10 lbs. hay, at night 4 qts. meal on the feed. This meal is corn, oats, and wheat ground together; 10 to 20 ears corn at a feed morning and noon. Colts about half as much as horses. A full ration per cow is 1 peck oat and wheat meal, 1 bundle fodder (stover), 12 lbs. hay, 6 lbs. chaff and a peck of beets. Heifers $\frac{1}{2}$ to $\frac{2}{3}$ of a cow ration; bulls, 1 bundle fodder, 12 lbs. hay, 6 lbs. oat straw. Sheep run in pasture the year round and are fed oats when needed.

Dr. W. R. Capehart, Avoca, Bertie County, has fed corn silage ten years and feeds it to all teams when not at work. Rations for cows: silage, cotton seed meal, and peanut vines; for beeves, silage and meal.

E. S. Saunders, Fayetteville, Cumberland County, in answer to "What feeds do you give sheep?" says: "Cannot say until we have a dog killing here. The dogs killed 13 sheep for me in one night. Then I sold out and quit the business."

*Mr. C. W. Garrett built upon this farm in 1879, and used with success the first silo ever constructed in North Carolina.

John Wilson, Coleraine, Bertie County, has kept about 75 Cotswold sheep. He says: "Have lost 50 ewes and, including their lambs, at least 100 head by dogs since last spring. Have only 24 head, now running on rye."

Messrs. Hackburn & Willet, Newbern, Craven County, report 100 Holstein-Friesian and 45 Jersey cows kept for milk. These cows are fed "about one bushel of corn silage twice a day and about 7 pounds of dry hay once a day." Dry cattle are self-supporting about 8 months. Rye and crimson clover are sown for winter pasture. About 50 horses and mules are kept. The mules at hard work are fed all the hay and corn they will eat. Horses are fed 12 lbs. hay and 12 qts. oats, or 8 to 12 qts. corn. Colts are fed mostly upon wheat bran and nice timothy hay in winter. Fattening stock are fed cotton-seed meal, hominy, and bran. Sheep are not profitable. Swine are fed on clover pasture and hominy when fattening.

W. A. Austin, Gibraltar, Union County, writing as to the use of silage, says: "I have not used it. I prefer grazing my stock during winter on green clover, rye and oats, to any silo-preserved food both for economy and nutriment. It is an easy matter to have plenty during winter to nourish stock on the farm without the silo since our climate is mild."

One other adverse criticism has been given on another food. E. W. Thompson, Macon, Warren County, says: "I think cotton-seed hulls are nearly worthless. I have tried them two years and think shucks are worth nearly double as much as the hulls." These hulls cost Mr. Thompson too much. It would be well to remember that they are like coarse wheat straw, or shucks in that they act as a mechanical filler and yet supply considerable amounts of carbohydrates only when they are well cleaned. They should be fed with comparatively large amounts of cotton-seed meal in order to realize much from them. See bulletin 93 for rations of hulls and meal.

These replies to queries have been extracted to show that the leading stock farmers in various special lines are feeding well, and that many model rations have been given. We are under obligations for the example and wise words of encouragement and counsel given. The replies given are but a few of those already received, but they are sufficient at present to encourage others, and especially beginners, and to show that obstacles can be overcome and fine stock raised here at low cost. This bulletin is issued for the purpose of calling attention to the rational principles underlying the subject of feeding animals; and, with the plain directions heretofore given, to help those who are feeling their way along, to take a better hold of the subject.

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